Development of a sustainable Waste Management Concept (WMC) for Khanty-Mansiysk, Russia

Final Report

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- Итоговый Доклад Концепции Обращения с Отходами
- Annex I Status-quo-report
- Приложение I Доклад статус-кво
- Annex II Description of waste management technologies
- Annex III Development of scenarios
- Annex IV - Feasibility study - MBT under Siberian climate conditions
- Приложение IV Практическое обоснование МБО в условиях Крайнего севера

16. Kurzfassung

Die Autonome Region Khanty-Mansiysk - Ugra (KMAO-Ugra) erlebt seit 1990 eine rasante wirtschaftliche Entwicklung durch Erdgas- und Erdölförderung. Der Ausbau der Stadt Khanty-Mansiysk zur Regierungs- und Hauptstadt der Region brachte einschneidende Veränderungen: Infrastrukturprojekte, Wohnungsbau und die Eröffnung einer Universität wurden umgesetzt. Ein anhaltender Migrationsboom ist die Folge.

Bereits seit mehreren Jahren wird ein kontinuierlicher Anstieg der Abfallmengen in der Stadt Khanty-Mansiysk verzeichnet. In der Folge haben die aktuellen Methoden der Abfallentsorgung ihre Grenzen erreicht und die Abfallwirtschaft/ -entsorgung ist eines der wichtigsten Themen der lokalen Verwaltung in Khanty-Mansiysk geworden. Darüber hinaus wird die bestehende Deponie für die Ablagerung aller Arten von Abfällen, einschließlich gefährlicher oder problematischer Abfälle, wie z. B. medizinische Abfälle oder bestimmte Arten von industriellen Abfällen, verwendet. Die unsachgemäße Entsorgung von Abfällen kann zu ökologischen Problemen und Risiken für die menschliche Gesundheit führen. Weiterhin wurden bisher keine Recycling-Technologien zur Vermeidung von Abfall umgesetzt.

Um den oben genannten Problematiken entgegenzuwirken, war es notwendig, ein nachhaltiges städtisches Abfallwirtschaftskonzept zu entwickeln. In mehreren Treffen zwischen Vertretern der Stadtverwaltung von Khanty-Mansiysk (Abteilung für Stadthaushalt), der örtlichen Entsorgungsunternehmen (M DEP und andere private Unternehmen), des High-Technology Parks, der Staatlichen Universität Ugra in Khanty-Mansiysk sowie Umwelt-Experten aus Deutschland (Technische Universität Berlin/ Institut für Ökologie und des Instituts ARGUS e. V. Berlin), wurde diskutiert, in welcher Weise eine Kooperation initiiert werden kann, um ein Abfallwirtschaftskonzept (WMC) für Khanty-Mansiysk zu entwickeln.

Da das deutsche Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) und das Deutsche Umweltbundesamt (UBA) solche Kooperationen unterstützen, schlugen die deutschen Experten vor, ein Kooperationsprojekt im Rahmen des deutschen "Beratungshilfeprogramm des Bundesumweltministeriums für den Umweltschutz in Mittel- und Osteuropa, dem Kaukasus und Zentralasien" festzuschreiben. Das Programm ist ein Instrument von BMU und UBA, um den Transfer von Wissen, das

Deutschland aus eigenen Erfahrungen gesammelt hat, eine langfristige Integration von hohen Umweltstandards in den Teilnehmerländern wie Russland zu unterstützen und Impulse für eine nachhaltige Veränderung in der regionalen Entwicklung zu geben. Innerhalb dieses Programms wurde das Projekt "Entwicklung eines nachhaltigen WMC für die Stadt Khanty-Mansiysk, Russland" im Oktober 2010 genehmigt. Die Laufzeit des Projekts beträgt 20 Monate (bis Mai 2012).

Im Rahmen des russisch-deutschen Beratungsprojektes wurde vereinbart, ein Abfallwirtschaftskonzept für Siedlungsabfälle im Stadtgebiet von Khanty-Mansiysk zu entwickeln. Der Schwerpunkt des Konzeptes ist der Schutz der menschlichen Gesundheit und der Umwelt, Entsorgungssicherheit und eine deutliche Reduzierung der abgelagerten Abfälle. Weitere Teilziele sind, die Abfallwirtschaft in Khanty-Mansiysk zu stärken und die Möglichkeiten der Gewinnerzielung durch die Wiederverwertung von Abfällen bis hin zur Produktion und Vermarktung von Nebenprodukten und Sekundärbrennstoffen zu untersuchen. Schlussendlich wurden beständige Kontakte zwischen russischen und deutschen Entsorgungsunternehmen während der Umsetzung des Projekts initiiert.

17. Schlagwörter
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- Итоговый Доклад Концепции Обращения с Отходами
- Annex I Status-quo-report
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- Annex IV - Feasibility study - MBT under Siberian climate conditions
- Приложение IV Практическое обоснование МБО в условиях Крайнего севера

16. Abstract

Khanty-Mansiysk Autonomous Okrug - Ugra (KMAO-Ugra) started to play a main role in the Russian economy in the mid-1990s when key oil and gas extraction was located in this region. Hence, a migration boom started, incomes increased and the infrastructure improved, especially in the capital of KMAO-Ugra – Khanty-Mansiysk. A continuous rise in the amount of waste has been recorded in the municipality of Khanty-Mansiysk for several years. As a result, the current methods of waste disposal have reached their limits and therefore, the management of Municipal Solid Waste (MSW) is one of the main issues the local administration in Khanty-Mansiysk has to deal with. In addition, the landfill is used for deposition of all types of waste, including hazardous or problematic waste, such as medical waste or specific types of industrial waste. Furthermore, no recycling technologies have been implemented so far to minimise waste being landfilled.

These issues result in the improper disposal of waste and may cause environmental problems and risks to human health. Therefore, a sustainable urban waste management concept needed to be developed. In several meetings between representatives of the Department of city household – Administration of Khanty-Mansiysk, the local waste management company (M DEP), the High Technology Park, the Ugra State University in Khanty-Mansiysk as well as environmental experts from Germany (Technische Universität Berlin/ Institute of Ecology and the institute ARGUS e. V. Berlin), it was discussed in which way a co-operation could be initiated to develop a Waste Management Concept (WMC) for Khanty-Mansiysk.

As the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the German Federal Environment Agency (UBA) support such co-operations, the German experts proposed to stipulate a co-operation project within the framework of the German “Advisory Assistance Programme for Environmental Protection in the Countries of Central and Eastern Europe, the Caucasus and Central Asia”. The programme is an instrument of BMU and UBA in order to support the transfer of knowledge which Germany has gained from its own experiences, long-term integration of high environmental standards in participant countries such as Russia and to

<table>
<tr><td colspan="3">provide impetus towards sustainable change in regional development. Within the programme, the project “Development of a sustainable WMC for Khanty-Mansiysk municipality, Russia” was approved in October 2010. The term of the project amounts to 20 months until May 2012.
Within the scope of the Russian-German advisory project it was agreed to develop a waste management concept for MSW in the urban area of Khanty-Mansiysk municipality. The main focus of the concept is the protection of human health and the environment, safeguard of disposal security and a significant reduction of landfilled waste. Further sub-objectives are to strengthen the waste management in Khanty-Mansiysk and to explore the possibility of gaining profit from recycling waste through production and marketing of secondary products and fuels. Finally, continuous contacts between Russian and German waste disposal companies are established during the implementation of the project.</td></tr>
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ABBREVIATIONS AND UNITS

BMU	The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
CDM	Clean Development Mechanism
CIS	Commonwealth of Independence
EoI	End-of-life
GDP	Gross Domestic Product
H&CW	Household & Commercial Waste
KM municipality	Khanty-Mansiysk municipality
KMAO-Ugra	Khanty-Mansiysk Autonomous Okrug – Ugra
M DEP	Municipal Road – Operational Enterprise
MBT	Mechanical-Biological Treatment plant
MSW	Municipal Solid Waste
PE	Polyethylene
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinylchloride
RDF	Refuse Derived Fuel
SPP	Sorting and Processing Plant
SWM	Solid Waste Management
UBA	German Federal Environment Agency
WM	Waste Management
WMC	Waste Management Concept

kg c^{-1} a^{-1}	Kilogrammes per capita and year
kg c^{-1} w^{-1}	Kilogrammes per capita and week
Mg	Megagram (1Mg = 1,000kg = 1 ton)
Mg a^{-1}	Megagrammes per year
KJ kg^{-1}	Kilojoule per Kilogrammes

1 INTRODUCTION AND OBJECTIVES OF THE PROJECT

Khanty-**M**ansiysk **A**utonomous **O**krug - Ugra (KMAO-Ugra) started to play a main role in the Russian economy in the mid-1990s because key oil and gas extraction is located in this region. Hence, a migration boom started, incomes increased and the infrastructure improved, especially in the capital of KMAO-Ugra – **K**hanty-**M**ansiysk (KM municipality). As a result, a continuous rise in the amount of waste has been recorded in KM municipality for several years.

The management of **M**unicipal **S**olid **W**aste (MSW) is one of the main problems for the public administration in Khanty-Mansiysk because the current methods of waste disposal have reached their limits. According to official statements, the places prepared for waste disposal on the only landfill have already reached their current deposition capacity; i. e. new places for landfilling have to be allocated. In addition, the landfill is used for deposition of all types of waste, including waste important in volume, such as construction and demolition waste and hazardous or problematic waste, such as medical waste or specific types of industrial waste. Furthermore, no recycling technologies are implemented so far to divert waste from being landfilled. These issues result in the improper disposal of waste and may cause environmental problems and risks to human health.

Therefore, a sustainable urban waste management concept in Khanty-Mansiysk needs to be developed that aims at protecting human health, reducing environmental pollution and achieving a minimised use of natural resources. Furthermore the concept safeguards disposal security and a significant reduction of waste to be landfilled.

In several meetings between representatives of the former Department of town-planning, architecture and housing and communal services (replaced since in 01/2012 by the Department of city household – Administration of KM), the local waste management company (M DEP), the enterprise EKOTEK, the High Technology Park, the Ugra State University from Khanty-Mansiysk as well as environmental experts from Germany (Institute of ecology at the Technical University Berlin and the institute ARGUS e. V. Berlin), it was discussed in which way a co-operation could be started to develop a sustainable **W**aste **M**anagement **C**oncept (WMC) for Khanty-Mansiysk.

The German Experts proposed to stipulate a co-operation project in the framework of the German “Advisory Assistance Programme for Environmental Protection in the Countries of Central and Eastern Europe, the Caucasus and Central Asia” focusing on the development of a WMC. The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the German Federal Environment Agency (UBA) support such co-operations. The “Advisory Assistance Programme” was introduced as an instrument by the BMU and UBA in order to support the transfer of knowledge which Germany has gained from its own experiences, long-term integration of high environmental standards in participant countries such as Russia as well as providing impetus towards sustainable change in regional development. Within the programme, the project “Development of a sustainable WMC for KM municipality, Russia” was approved in October 2010. The term of the project amounts to 18 months until May 2012.

The key objective of the project was the development of a sustainable WMC for KM municipality. Main focus of the concept is the protection of human health and the environment and the reduction of the volume of solid waste disposed on the landfill site. Further sub-objectives are to strengthen the waste management in Khanty-Mansiysk and to explore the possibility of gaining profit from recycling waste through production and marketing of secondary products and fuels. Finally, continuous contacts between Russian and German waste disposal companies as well as local municipalities will be established. All these tasks were carried out in effective co-operation and collaboration with the representatives of Khanty-Mansiysk administration and the Ugra-State University supported by M DEP[1], EKOTEK[2] and High Technology Park[3].

For the development of a sustainable waste management concept, relevant data and information about main waste flows and their properties (quantity and quality of waste generated, recycled and disposed), infrastructure of Khanty-Mansiysk, geographical/ geological and topographical conditions, existing waste management structure (collection, transportation and treatment/ disposal), national/ regional waste legislation and opportunities for recycling products were collected or analysed respectively. Therefore mainly interviews with representatives of local authorities, waste disposal companies as well as interviews with Russian and European (waste management) experts were carried out to gather the required information. Additionally, information was collected through literature studies and internet research. Furthermore, waste analyses were implemented in Khanty-Mansiysk in February and June 2011. Following, a market analysis and a prognosis of waste amount and composition were carried out.

All the data gathered through the above methods are crucial information required for the development of a sustainable WMC and are summarised in the status quo report (refer to ***Annex I*** to this report). Based on data from the status-quo report the current waste management situation (baseline scenario) and three waste treatment options (recycling scenario, incineration scenario and biological-treatment scenario) were developed and proposed. Basis for the selection and assembly of the different scenarios was a comprehensive summary of available and approved waste management technologies. The waste management technologies are fully described in ***Annex II*** to this report (Description of waste management technologies). The proposed scenarios also reflect the range of recovery and disposal options in Khanty-Mansiysk.

To find the best fitting waste management solution for KM municipality the three proposed waste management solutions were evaluated based on social, ecological and economic considerations; i. e. disposal security, environmental impacts, reduction of landfill volume, accordance with national law, accordance with the regional waste management concept and financial and technical feasibility of the different scenarios. The development of the

[1] M DEP means “Municipal Road - Operational Enterprise” and is simultaneously the largest and only governmental waste disposal company in Khanty-Mansiysk. Approximately 90% of the municipal waste is collected and transported to the landfill through M DEP. Furthermore, this organisation is responsible for the operation of the landfill for Khanty-Mansiysk.

[2] EKOTEK is a private waste disposal company and is mainly responsible for collection and transportation of waste from all kindergarten and schools in Khanty-Mansiysk.

[3] The High Technology Park is to advise and to support the governmental authorities regarding policy and decision making to provide innovative economic development as well as to promote small and medium-sized innovative enterprises in Khanty-Mansiysk Autonomous Okrug – Ugra.

scenarios, the evaluation and the decision making process is described in ***Annex III*** to this report (Development of Scenarios).

The proposed scenarios were intensively discussed with representatives of the Khanty-Mansiysk administration. It was decided to exclude the biological-treatment scenario and to go into deeper investigations with the recycling and the incineration scenario. At this stage of the project concrete information on costs, technical feasibility and impacts on the waste to be disposed on landfill site were required by the Russian partner for MBT-plants (recycling scenario) as well as for incineration plants. In particular the feasibility of the proposed MBT-technology under the severe climate conditions in Siberia was of specific interest. A feasibility study to investigate these serious questions was initiated. The results of the feasibility study can be taken from ***Annex IV*** to this report (Feasibility study - MBT under Siberian climate conditions).

Following the results of discussions with representatives of the Khanty-Mansiysk administration and the additional studies a sustainable WMC based on the recycling scenario has been carefully developed and was approved in December 2011 by the Department of town-planning, architecture and housing and communal services of KM[4].

The final waste management concept is introduced in detail in chapter 2. The description includes the relevant framework conditions (existing waste management infrastructure, characterisation of waste flows, waste treatment options, opportunities for recycling products, legal requirements and regional concept), the technical description of the concept, the expected environmental impacts and the estimated costs of implementation. Chapter 3 will raise weaknesses which have to be further investigated by feasibility studies. Chapter 4 will give practical recommendations for implementing the project.

Scope of investigation

In general, scope of the investigation of a waste management concept is the total waste generated in a defined area. Waste is generated by industrial, commercial or private activities and defined as any substance or object which the holder discards or intends or is required to discard[5]. With regard to collection & transport, treatment and disposal waste has to be distinguished into the categories hazardous - non-hazardous, industrial – non-industrial and relevant in volume – not relevant in volume.

In the framework of the Russian-German advisory project it was agreed to develop the waste management concept for MSW from private households and commerce (Household waste and waste similar to household waste) in the urban area of KM municipality. MSW is collected in open containers near to the waste generator (private households and commerce) and the share of MSW at the total waste registered at the landfill site is 83%.

4 Note: This department was re-named in January 2012. The current name is: Department of city household – Administration of KM municipality.

5 Definition according to the European Waste Framework Directive (Directive 2008/98/EC)

It can be expected, that a significant part of industrial waste and hazardous waste is stored at the production site or disposed together with MSW. Construction & demolition waste is brought to the inert landfill site (amount is unknown) or disposed together with MSW as well.

Industrial waste, hazardous waste and waste relevant in volume (e. g. construction and demolition waste) could not be further investigated in the framework of the project. For these waste streams we can give only general recommendations for prevention, separation and their disposal. It is highly recommended to investigate the potential of industrial and hazardous waste in Khanty-Mansiysk and to supplement the waste management concept by these waste streams.

Moreover the Russian-German advisory project provides important impulses to implement the joint waste management concept. Therefore the project addressed administrative and organizational measures, the risks and opportunities of implementing the waste management concept, further need for feasibility studies and pilot projects and a detailed implementation plan.

2 FINAL WASTE MANAGEMENT CONCEPT

The first step developing a Waste Management Concept is a thorough investigation of the current waste management situation, description of applicable waste management technologies, summary of the main legal requirements regarding to waste management, investigation of recycling activities and opportunities for recycling products and the consideration of socio-economic aspects (willingness of the population to pay for an upgraded waste management service). All these information has been collected, analysed, assessed and evaluated in the framework of the project. In most cases, information about waste composition and relevant physico-chemical properties has to be investigated by a waste analysis campaign.

In the next step a selection of most appropriate waste management solutions (scenarios) out of multiple theoretically possible solutions has to be made, considering the relevant waste related information. Each pre-selected scenario has to be described in detail. The description comprises the organisational tasks, the proposed technology, the waste flows and its properties, the sales markets for recycling products, the expected environmental impact, the estimated costs etc. The final step developing a Waste Management Concept is the assessment and evaluation of the pre-selected scenarios by using economic, ecologic and social criteria. The development of a WMC can be taken from the flow diagram in figure 1.

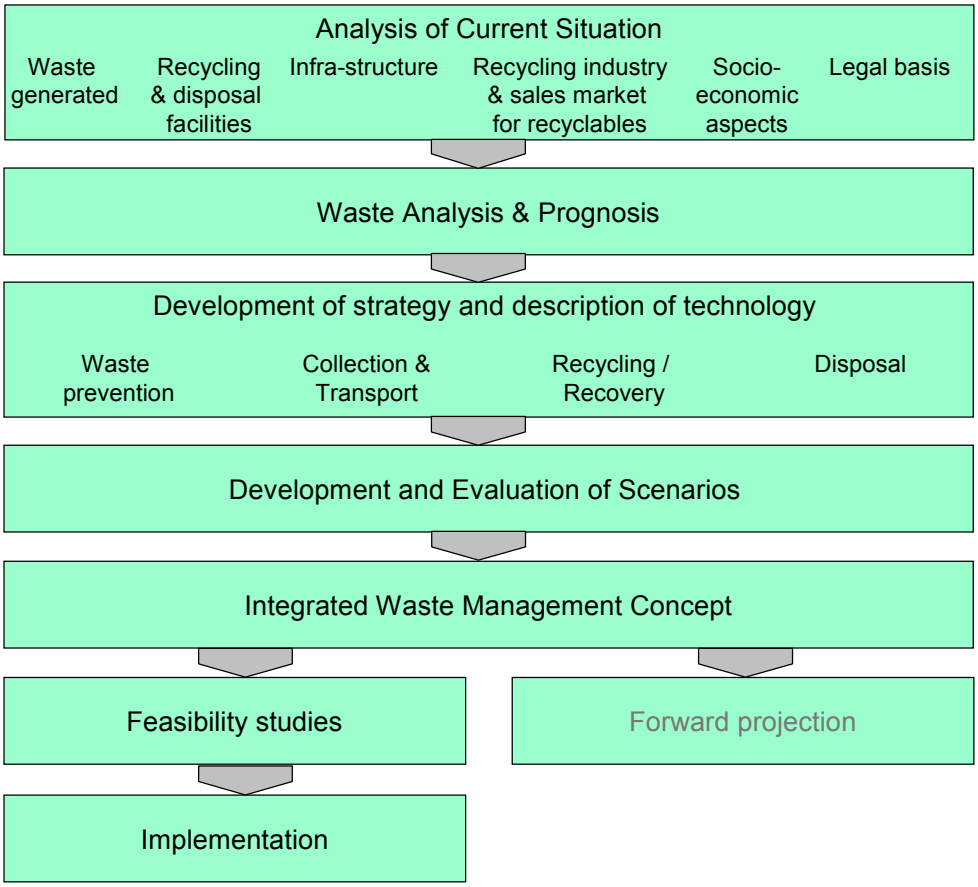

figure 1: Development of a Waste Management Concept

2.1 Relevant framework conditions

For a thorough understanding of the final WMC the following sections will provide a summary of relevant framework conditions. The underlying detailed information can be taken from ***Annexes I to IV*** to this report. The relevant framework conditions can be divided into the fields

- General aspects related to waste management
- Existing Waste management infrastructure
- Characterisation of waste flows
- Waste treatment options
- Opportunities for recycling products
- Legal requirements
- Regional waste management concept

2.1.1 General aspects related to waste management

The proposed SWM project intends to upgrade the existing waste management practices by proposing a waste management concept. With all project members it was jointly agreed, that the project area consists of the area of the Khanty-Mansiysk municipality. The period under consideration has been determined for a planning horizon of 12 years (2012-2024).

Geography

Khanty-Mansiysk Autonomous Okrug – Ugra is located in Western Siberia in the Russian Federation. KMAO-Ugra has a north-south length of 900 km and a west-east length of 1,400 km. The size of the area is 534,800 km^{2}[6] (53,480,000 ha) and occupies 3% of the entire area of Russia (17.1 million km^2).

Khanty-Mansiysk municipality is the capital of Khanty-Mansiysk Autonomous Okrug-Ugra (KMAO-Ugra). Samarovo, the original settlement, was founded in 1637 and is a part of Khanty-Mansiysk today. At present, the area of the town is 33.7 km^2. Khanty-Mansiysk is located on the 61.1st degree of latitude and 69.2nd degree of longitude, in the centre of the West Siberian Plain. It is situated where the rivers Ob and Irtysh flow together. The town is 930 km north from Tyumen[7] and 2,900 km east from Moscow (see figure 2)[8].

[6] Administration of KMAO-Ugra, 2011a

[7] Note: Tyumen is the capital of the Tyumen Oblast in West Siberia. KMAO-Ugra is an autonomous region of the Tyumen Oblast.

[8] Administration of Khanty-Mansiysk, 2011

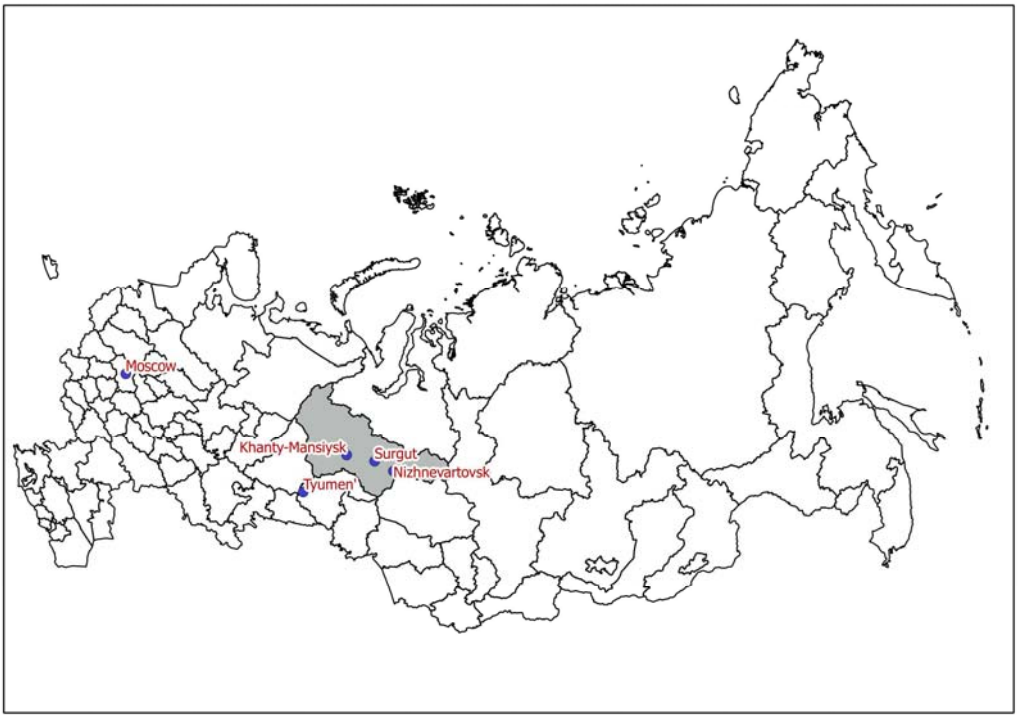

figure 2: Geographical position of Khanty-Mansiysk Autonomous Okrug[9]

KMAO-Ugra is subdivided into 9 municipal districts, 13 towns[10] (see figure 3), 26 small towns and 175 villages[11]. The territory of KMAO-Ugra is covered by approximately 40% forest on mineral soils, 35% bogs and swamps, 20% forested bogs and fens, and 5% meadows on river floodplains[12]; approximately 60% of the area of KMAO-Ugra is covered by river floodplains, bogs, swamps and meadows.

Land use

The pre-dominant land use in KMAO-Ugra is forest resources land/ forest management land (91%). Protected areas account for only 5.7% of land area. Furthermore, 1.3% of the area are covered by towns and villages as well as roads and industrial areas. 1.3% of the land is used for agriculture[13]. Besides a few cattle breeding farms, agricultural activities are limited to mowing of a small part of the floodplain grassland. Agricultural products have to be imported from other parts of Russia[14]. In addition, 1% of the area of KMAO-Ugra accounts for water/ rivers[15].

[9] Filippova, 2011a
[10] Administration of KMAO-Ugra, 2011a
[11] Government of KMAO-Ugra, 2004
[12] Government of KMAO-Ugra, 2004
[13] Government of KMAO-Ugra, 2004
[14] Administration of KMAO-Ugra, 2011a
[15] Government of KMAO-Ugra, 2004

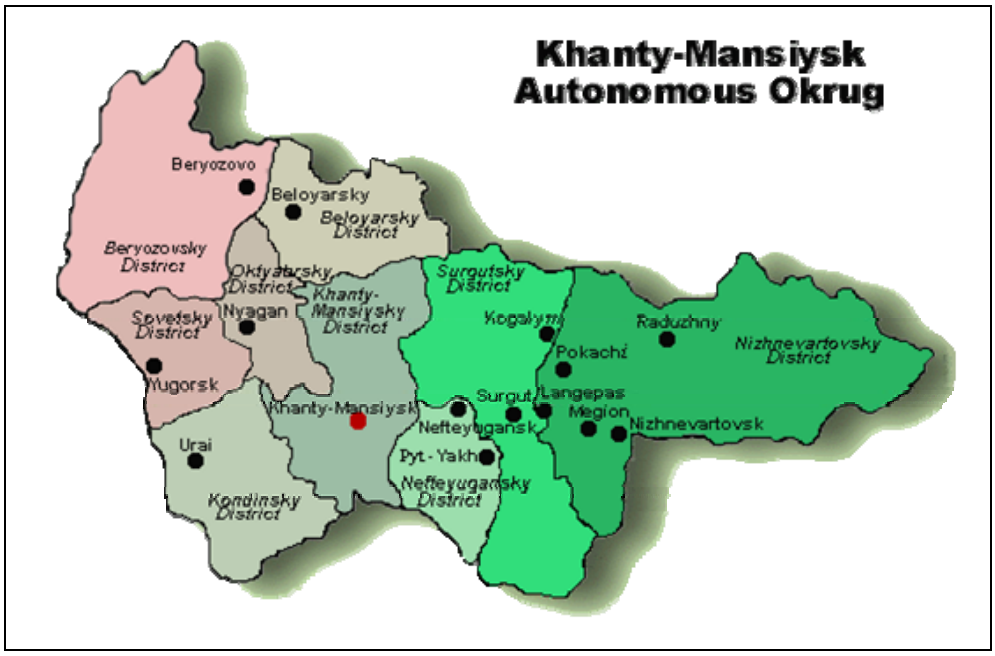

figure 3: Subdivision of KMAO-UGRA into 9 municipal districts and 13 towns (Note: Beryozovo and Beloyarsky are urban settlements and do not have a status of a town. They are the administration centre of Beryozovo district and Beloyarsky district.)[16]

Geology and topography

Not only the geographical position but also the terrain's profile, the geology as well as the hydrology are site-specific conditions that play an important role for searching suitable places for waste treatments plants, particularly landfill sites. There are three basic types of soils close to Khanty-Mansiysk: podzol, bog-podzol (forest and bogged forest sites) and alluvial (floodplain sites)[17].

The structure of geological stratum near KM is very complex. The elevated part ("Samarovskiy Hills") consists of river sediment caused by ice melting. Clay, loam and sandy sediments have been formed and in some places deeper clay material, oversaturated with water has been pushed upwards. Along the slopes of the raised peninsula, colluvial deposits with three Pleistocene terrace levels are present. The floodplains of rivers Ob and Irtysh consist of light clays, sandy clay, clay loam and loams. In the (former) river channels riverbed load deposits consist of sand and gravel[18] (for more information on the geological and topological formations see ***Annex I*** to this report).

In summary, the existing hydrology plus the vast area of wetlands extremely limit the options for locating waste treatment plants and/ or landfills in the area around Khanty-Mansiysk. Therefore, these natural conditions have an essential influence on the proposal of a site for waste treatment plants and/ or landfill as part of developing a waste management concept for Khanty-Mansiysk. Furthermore, there is a high risk of pollution of ground and drinking water

[16] Administration of KMAO-Ugra, 2011b

[17] Ugra Department of Russian Geographical Society, Ugra State University – Institute of Second Education, 2007

[18] Ugra Department of Russian Geographical Society, Ugra State University – Institute of Second Education, 2007

as well as environmental pollution. The construction of the landfill would have to meet specific requirements in order to prevent uncontrolled infiltration of (ground) water into the body of the landfill and visa verse. However, the landscape is flat and uncontrolled leakage of leachate can be prevented through the construction of a landfill. The existing clay layers can work as a natural barrier. Finally, the high level of ground water, the site restrictions caused by bogs, swamps and river floodplains, the special protection of ground and drinking water will have an influence on the costs for re-construction and re-cultivation of the current existing landfill as well as on the costs for the construction of a new landfill site.

Climate

As KMAO-Ugra shows severe climate conditions, i.e. very long and cold winter periods and short and hot summer periods, and the typical vegetation zones for this climate, both, climate and vegetation need to be considered for the development of an urban waste management concept. Especially, the climate has an impact on the selection of the collection system as well as on the selection of adequate treatment plants, especially for biological waste treatment plants.

In KMAO-Ugra, the climate is almost continental with an average temperature range between -18°C and -24°C in January as well as between 16°C and 18°C in July[19]. The average rainfall rate is 400-550 mm per year in KMAO-Ugra (see figure 4).

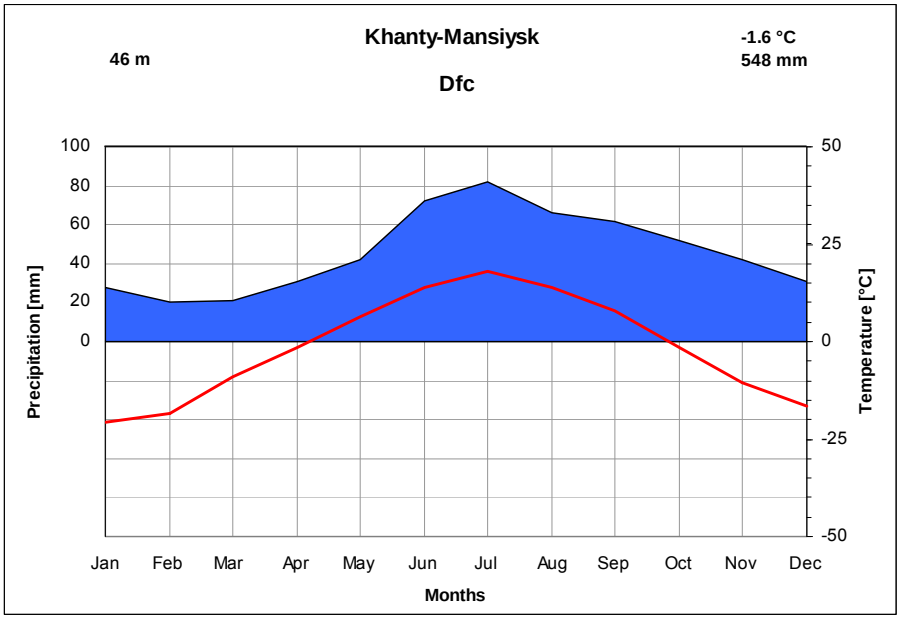

figure 4: Climatic diagram for Khanty-Mansiysk[20]

Because of severe climate conditions in Khanty-Mansiysk, i.e. very long and cold winters and short and hot summer periods, the biological waste treatment methods are effected by these

[19] Administration of KMAO-Ugra, 2011a

[20] Mühr, 2007

conditions. It can be assumed, that the treatment facilities has to be encapsulated and heated during winter times.

Transport routes

Khanty-Mansiysk is connected with other towns in KMAO-Ugra and towns in Siberia mostly via federal roads. The nearest towns which can be reached by the road system are Py'tach (250 km), Neftyuganz (160 km), Surgut (300 km) and Njangang (250 km). The most important connections via road are the ones to Neftyuganz and Surgut – as they are the biggest towns in KMAO-Ugra. Another important connection is the road to Py'tach as there is the closest railway station to Khanty-Mansiysk. All these towns are located in the south of Khanty-Mansiysk.

The intra-urban and federal roads are useable for heavy transport. A well organised winter service cleans the roads quickly and efficient and therefore, the roads are passable for all types of transportation for the entire year.

As KMAO-Ugra is dominated by the river system of the Ob and Irtysh, cargo is also transported by ship on the rivers Ob, Irtysh and their tributary rivers. Approximately 2 million tons of cargos (such as raw materials and materials for construction) are transported by water ways per year[21] and so, cargo transport via ship is an important factor within the transport logistics in KMAO-Ugra. The water ways connect Khanty-Mansiysk with towns outside of KMAO-Ugra such as Omsk, Tobolsk, Tomsk and Novosibirsk in the south of Khanty-Mansiysk and Salekhard in the north of Khanty-Mansiysk. Furthermore, the water ways have access to the sea in the north.

Although the transportation of cargo via water system plays a significant role in the transport logistic system of KMAO-Ugra (69 % of transportation is implemented via water and railway system in KMAO-Ugra[22]), it is limitedly available. The water ways are not passable during the winter period which is seven months per year.

KM municipality is not connected to the KMAO-Ugra's railway system. The nearest train stations to Khanty-Mansiysk are in Py'tach (250 km) and in Surgut (300 km). There is transport of cargo possible at the railway stations in Py'tach and in Surgut (equipment for loading and un-loading of cargo is available such as cranes[23]).

These infrastructural conditions have influence on waste treatment facilities and locations. Although Khanty-Mansiysk is well integrated into the federal roads and navigable water systems as well as its local roads being in a good condition, Khanty-Mansiysk is relatively isolated compared to other towns in KMAO-Ugra such as Surgut and Neftyuganz. As Khanty-Mansiysk is not connected to the railway, waste transport via railway system would require transportation to the railway stations in Surgut or Py'tach. Despite the restrictions shipments via water should be considered for long distances.

[21] Administration of KMAO-Ugra, 2011d

[22] Administration of KMAO-Ugra, 2011a

[23] Popova, 2011, interview

Socio-economic aspects

The implementation of a new waste management system has to consider the main socio-economic characteristics of the households, which will have to bear the potential additional costs. Therefore it is important to know the average and distribution of the household income and the affordability and willingness of the population to pay customer fees.

The average income of the people in KMAO-Ugra is approximately 1.000 EUR/mo (***Annex I***, chapter 2.6.3) respective 330 EUR/mo/cap with an assumed average household size of 3 persons. Currently, the inhabitants of KM pay 22.6 Euro per capita and annum for waste management[24] [Department of city household]. This means, that households in KM municipality are paying 0,45% of their average income for WM. The World Bank states a range of 0.7 to 2.5% of the income of a household to be affordable for SWM services.

Further socio-economic indicators are

- the part of families connected to any social security system,
- the unemployment rate
- the share of inhabitants with regular income

These indicators should be analysed by the municipality before implementing waste management systems. Since the socio-economic conditions cannot be eliminated on short or medium terms, it is important to carry out awareness raising campaigns to educate the public about the new WMC, thus increasing the willingness-to-pay and the acceptance of the new WMC among the population. Only then it will be possible to ask for an increased fee for waste management.

2.1.2 Existing waste management infrastructure

In order to evaluate the present performance of SWM services in KM municipality the collection and transport system as well as the treatment and disposal facilities have been analysed. Following main waste streams could be identified in KM municipality.

(1) **H**ousehold & **C**ommercial **W**aste (H&CW)
(2) Bulky Waste and Construction & Demolition Waste
(3) **E**nd-**o**f-**l**ife tyres (Eol tyres)
(4) Medical Waste
(5) Street Cleaning Residues and waste from litter bins, garden & park waste, market waste
(6) Waste from veterinary clinics (including dead animals from livestock farms and pets)
(7) Industrial Waste; can not be differentiated in KM from H&CW Waste

[24] Department for City Household – Administration of Khanty-Mansiysk: According to the charge for disposal (regulation No 85; 16.11.2010) and the charge for collection and transport (protocol from 29.12.2010), 1m^3 of municipal solid waste (including collection, transport and disposal) costs 486.67 Roubles (12.81 Euros; 1 Euros = 38 Roubles). Relating the norm of production of waste in KM (from 29.12.2006), 1.754m^3 of municipal solid waste per year were produced of each inhabitant. In total, 858.49 Roubles (23 Euros) per year has to be paid by each inhabitant of KM for collection, transport and disposal municipal solid waste.

H&CW, Bulky Waste and Construction & Demolition Waste and Industrial Waste, which can not be differentiated in KM from H&CW, are collected by a pick-up system as mixed MSW. The pick-up system consists of collecting the waste daily through waste containers on public streets and disposing of the entire waste generated on the landfill. In Khanty-Mansiysk more than 2.000 mobile waste containers (most of them have a volume of about 0.5 m^3) are picked up daily by refuse collection vehicles, which are of rear end loaded. Besides this regular waste collection there are a number of uncontrolled and illegal waste dumpsites on the outskirts of Khanty-Mansiysk (near forest areas), were people of KM municipality dispose their waste. These places have to be cleaned on the premises of the municipality in regular intervals. Separately collected construction & demolition waste is brought to an inert landfill. The street cleaning residues and waste from litter bins, garden & park waste, market waste are collected separately by street-cleaning vehicles. Medical waste is collected separately and sterilised before disposal. End-of-life tyres are collected separately as well or sorted out from the MSW before disposal at the landfill site. Paper and metals are collected separately from household & commercial waste and from bulky waste and construction & demolition waste by door to door collection or are brought to the recycler by self delivery. Waste from veterinary clinics (including dead animals from livestock farms and pets) is disposed of in a special prepared bunker on the landfill site for sterilisation.

There are no recycling facilities in KM municipality so far. Only few and small companies exist to carry out the collection trading of different waste streams (scrap and paper dealers[25]). The waste which is collected by the municipality is transported directly to the landfill. Medical waste and waste from veterinary clinics (including dead animals from livestock farms and pets) are treated in a sterilisation facility before stored on the landfill site. End-of-life tyres were separated before disposal. All other waste types are disposed on the landfill site without any further treatment.

Besides the regular landfill site, there are landfill site for snow and demolition waste as well as several uncontrolled dumpsites in the outskirts of KM, used by the population. The regular landfill site is located approximately 17km from the town, due north-east. In this direction (north-east) of the town, there are also many dachas located including several uncontrolled dumpsites. Construction waste and snow are disposed of due west of Khanty-Mansiysk, close to the river Irtysh.

On the regular landfill site, the existing soil (mainly clay and sandy clay) is protected from the waste and any contamination by a layer of rubber. However, the regular landfill site doesn't have a further specified underground sealing.

The landfill sites for snow and demolition waste as well as the uncontrolled dumpsites don't have any kind of underground sealing. The floodplains of rivers Irtysh consist of clay loam and loams; the area of uncontrolled dumpsites includes (like the area of the regular landfill site) mainly clay and sandy clay.

[25] The company "Ekobalance" collects and transports paper and cardboard in KM municipality. It has contracts with different business companies and administrational organisation that the paper and cardboard produced is to be stored separately next to the waste container of the business or administrational organisation. The company collects the separated material, stores it in a storage hall and transports it to other towns, such as Yekaterinburg, for further treatment.

Besides the regular landfill site, there are several uncontrolled dumpsites in the outskirts of KM municipality, used by the population. The landfill site and the other uncontrolled dumpsites are located in either natural depression. The landfill site doesn't have a further specified underground sealing, the uncontrolled dumpsites don't have any kind of underground sealing.

The landfill site and the disposal of waste is the responsibility of the regional government. The site is operated by M DEP, the local public waste management company in KM. The landfill site is equipped by a building entrance, a vehicle hangar, weighing bridge, a tire washing facility, roads, fences, gates, appropriate equipment for landfilling and all electrical installations.

The current waste management system implemented in Khanty-Mansiysk is described schematically in figure 5.

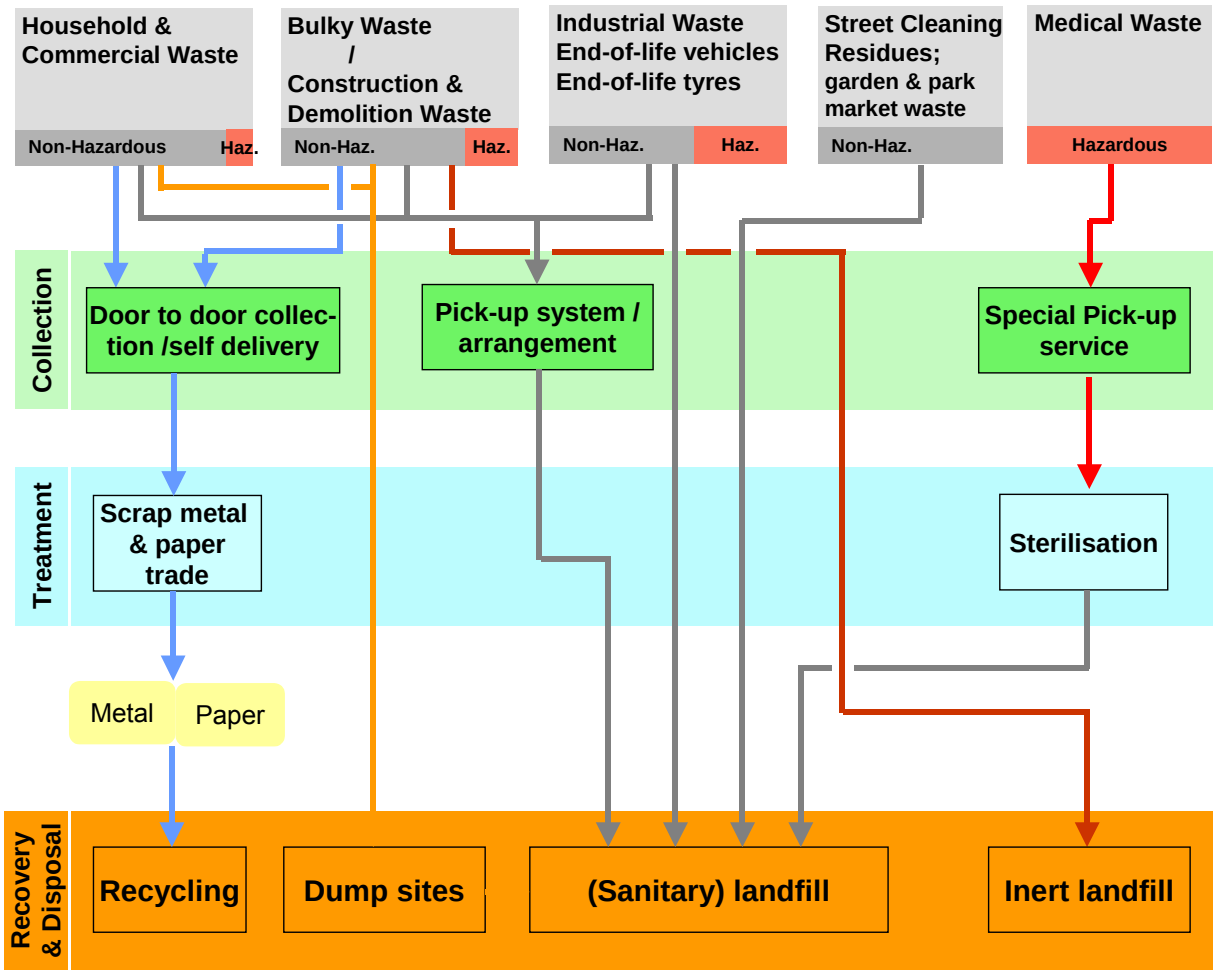

figure 5: Current waste management system in Khanty-Mansiysk

2.1.3 Characterisation of waste flows

The analysis of waste forms the basis for the development of waste management concepts as well as for the planning of recycling, treatment and disposal plants. The successful planning of a sustainable WMC and its implementation depends on reliable data of the current waste amount and composition (including relevant physico-chemical properties) and the prediction accuracy of solid waste generation for a relevant planning period. For this reason, two waste analyses campaigns (winter and summer) were conducted in 2011 to characterise the material composition and the water content of the main waste flow, municipal solid waste from households & commerce. Based on this empirical data, the amounts of waste and their material composition and properties were predicted by waste prognoses. Prognoses are essential for selecting a suitable type of future waste disposal, for the size of waste treatment plants as well as for the decision of utilisation of waste such as recycling.

According to the calculations done by ARGUS e. V., the generation of H&CW will increase from 25,800 Mg a^{-1} in 2010 to 50,500 Mg a^{-1} in 2024 in Khanty-Mansiysk; i. e. the amount of household waste including commercial waste, will be doubled in the next 14 years (see table 1 and figure 6). Furthermore, it can also be expected that the amount of bulky waste, construction & demolition waste, street cleaning waste, waste from veterinary clinics (including dead animals from livestock farms and pets) and end-of-life tyres will increase significantly.

table 1: Prognosis of municipal waste until 2024 [Mg a^{-1}]

Waste types	2010	2012	2014	2016	2018	2020	2022	2024
Household Waste & Commercial Waste	25.784,9	28.737,3	32.027,8	35.351,1	39.019,1	43.067,7	46.617,9	50.460,7
Household Waste	21.917,2	24.426,7	27.223,7	30.048,4	33.166,2	36.607,6	39.625,2	42.891,6
Commercial Waste (similar to household waste)	3.867,7	4.310,6	4.804,2	5.302,7	5.852,9	6.460,2	6.992,7	7.569,1
Bulky waste & construction & demolition waste	3.410,0	3.800,5	4.235,6	4.675,1	5.160,2	5.695,6	6.165,1	6.673,3
Sum of other waste types	1.921,8	2.141,8	2.387,0	2.634,7	2.908,1	3.209,8	3.474,4	3.760,8
Medical waste	180,0	200,6	223,6	246,8	272,4	300,6	325,4	352,3
Street cleaning residues and waste from litter bins, Garden and park waste, market waste	1.428,0	1.591,5	1.773,7	1.957,8	2.160,9	2.385,1	2.581,8	2.794,6
Veterinary medicine waste	0,8	0,8	0,9	1,0	1,1	1,3	1,4	1,5
End-of-life tyres	313,0	348,8	388,8	429,1	473,6	522,8	565,9	612,5
Total	**31.116,7**	**34.679,6**	**38.650,5**	**42.660,9**	**47.087,4**	**51.973,2**	**56.257,4**	**60.894,9**

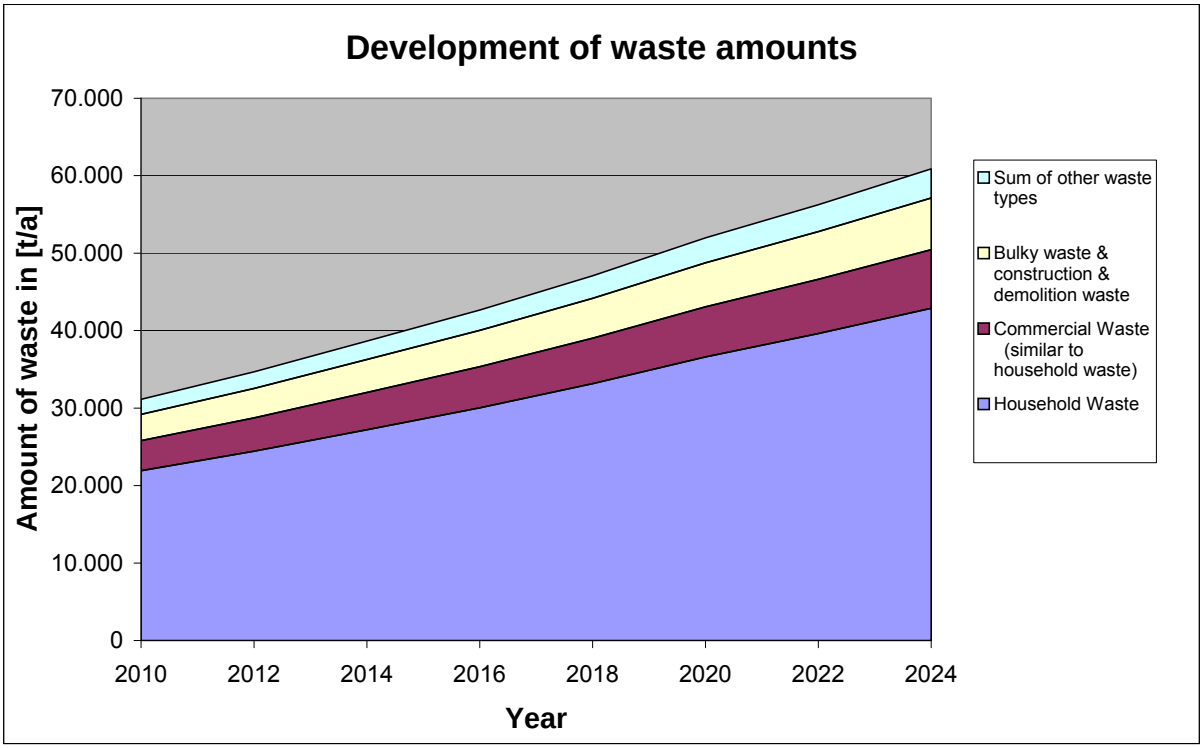

figure 6: Development of MSW in Khanty-Mansiysk from 2010 to 2024

Besides the amounts of the main waste types the composition of mixed waste is also of great interest. The composition of household & commercial waste in Khanty-Mansiysk was investigated by a waste analysis, carried out in the framework of the project in 2011 (The waste analysis and the results are described in detail in ***Annex I*** to this report).

The composition of H&CW is given in figure 7. The total annual amount of H&CW in Khanty-Mansiysk was calculated as 25,800 Mg a^{-1} in 2010. The household & commercial waste consists mainly of organic (34%), glass (13%), plastic (12%) and paper (11%). These fractions comprise 69% of the total waste composition in Khanty-Mansiysk. Almost all other fractions (except fines and metals) are below 5%.

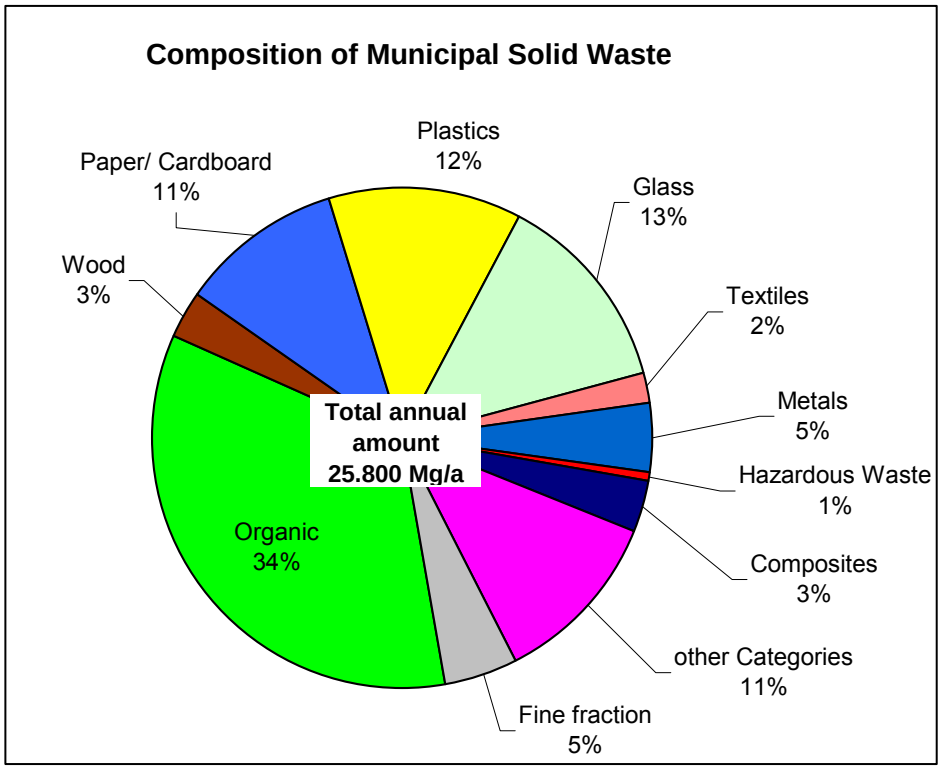

figure 7: Composition of municipal solid waste in Khanty-Mansiysk in 2010

Based on the composition of H&CW in 2010, the waste amounts of each fraction were predicted until 2024. The waste prognosis considers the expected development of the population and the economy in Khanty-Mansiysk. For further information, see calculation of prognosis in ***Annex I*** to this report. The waste composition and the predicted amounts until 2024 can be taken from table 2 for the main categories (first category) and in table 3 for the sub-categories (second category). The figure 8 presents the visual results of the development of the waste composition of MSW.

table 2: Prognosis of household & commercial waste composition 2010 to 2024 (1st category)

1st Category	2010	2012	2014	2016	2018	2020	2022	2024
Organic	8.882,2	9.899,2	11.032,7	12.177,5	13.441,0	14.835,7	16.058,6	17.382,4
Wood	768,1	856,1	954,1	1.053,1	1.162,3	1.283,0	1.388,7	1.503,2
Paper/ Cardboard	2.758,6	3.074,5	3.426,5	3.782,1	4.174,5	4.607,6	4.987,5	5.398,6
Plastics	3.201,9	3.568,5	3.977,1	4.389,8	4.845,3	5.348,0	5.788,9	6.266,1
Glass	3.374,8	3.761,2	4.191,8	4.626,8	5.106,9	5.636,8	6.101,4	6.604,4
Textiles	501,7	559,2	623,2	687,8	759,2	838,0	907,1	981,8
Metals	1.162,2	1.295,3	1.443,6	1.593,4	1.758,7	1.941,2	2.101,2	2.274,4
Hazardous Waste	134,2	149,6	166,7	184,0	203,1	224,2	242,7	262,7
Composites	859,6	958,0	1.067,7	1.178,5	1.300,7	1.435,7	1.554,1	1.682,2
Other Categories	2.927,2	3.262,4	3.636,0	4.013,2	4.429,7	4.889,3	5.292,3	5.728,6
Fine fraction	1.214,3	1.353,4	1.508,3	1.664,8	1.837,6	2.028,2	2.195,4	2.376,4
Total	**25.784,9**	**28.737,3**	**32.027,8**	**35.351,0**	**39.019,1**	**43.067,7**	**46.617,9**	**50.460,7**

table 3: Prognosis of household & commercial waste composition 2010 to 2024 (2nd category)

2nd category	2010	2012	2014	2016	2018	2020	2022	2024
Biodegradable Kitchen/Canteen Waste	7.905,9	8.811,2	9.820,1	10.839,0	11.963,7	13.205,1	14.293,6	15.471,8
Biodegradable Garden/Park Waste	522,5	582,4	649,0	716,4	790,7	872,8	944,7	1.022,6
Other Biodegradable Waste	453,7	505,7	563,6	622,1	686,6	757,9	820,3	887,9
Wood untreated	374,5	417,4	465,2	513,4	566,7	625,5	677,1	732,9
Wood treated	393,6	438,7	488,9	539,6	595,6	657,4	711,6	770,3
Non-biodegradable paper	163,0	181,7	202,5	223,5	246,7	272,2	294,7	319,0
Paper/cardboard – packaging	1.202,8	1.340,5	1.494,0	1.649,0	1.820,1	2.009,0	2.174,6	2.353,9
Paper/cardboard– non packaging	1.200,1	1.337,5	1.490,7	1.645,3	1.816,1	2.004,5	2.169,7	2.348,6
Newspapers	192,7	214,8	239,4	264,2	291,6	321,9	348,4	377,2
Plastic Film – packaging	1.353,5	1.508,5	1.681,2	1.855,7	2.048,2	2.260,7	2.447,1	2.648,8
Plastic Film – non packaging	243,9	271,8	302,9	334,3	369,0	407,3	440,9	477,2
Dense Plastic – packaging	1.254,3	1.397,9	1.558,0	1.719,6	1.898,1	2.095,0	2.267,7	2.454,6
Dense Plastic – non packaging	350,2	390,3	435,0	480,2	530,0	585,0	633,2	685,4
Clear Glass Packaging	1.947,4	2.170,3	2.418,9	2.669,8	2.946,9	3.252,6	3.520,7	3.811,0
Brown Glass Packaging	383,8	427,8	476,8	526,2	580,9	641,1	694,0	751,2
Other Glass Packaging	850,5	947,8	1.056,4	1.166,0	1.287,0	1.420,5	1.537,6	1.664,4
Miscellaneous Non Packaging Glass	193,1	215,2	239,8	264,7	292,2	322,5	349,1	377,9
Clothes	316,8	353,1	393,5	434,4	479,4	529,2	572,8	620,0
Non-clothing textiles	184,9	206,1	229,7	253,5	279,8	308,8	334,3	361,8
Ferrous Packaging	263,4	293,5	327,1	361,1	398,5	439,9	476,2	515,4
Miscellaneous Ferrous	670,3	747,0	832,6	919,0	1.014,3	1.119,6	1.211,9	1.311,8
Aluminium Packaging	171,9	191,5	213,5	235,6	260,1	287,1	310,7	336,3
Miscellaneous Non-ferrous	56,7	63,2	70,4	77,7	85,7	94,6	102,4	110,9
Batteries/Accumulators	9,2	10,3	11,4	12,6	13,9	15,4	16,6	18,0
Miscellaneous hazardous waste	125,0	139,4	155,3	171,4	189,2	208,9	226,1	244,7
Composite Packaging	576,8	642,9	716,5	790,9	872,9	963,5	1.042,9	1.128,9
Composite Non-packaging	81,3	90,6	101,0	111,4	123,0	135,8	147,0	159,1
WEEE	201,4	224,5	250,2	276,2	304,8	336,5	364,2	394,2
Soil and Stones	385,7	429,8	479,1	528,8	583,6	644,2	697,3	754,8
Other inert	1.384,6	1.543,1	1.719,8	1.898,2	2.095,2	2.312,6	2.503,2	2.709,6
Nappies	611,0	681,0	759,0	837,7	924,7	1.020,6	1.104,7	1.195,8
Health Care/Biological Wastes	66,0	73,5	81,9	90,5	99,8	110,2	119,3	129,1
Miscellaneous Categories	480,0	535,0	596,2	658,1	726,4	801,7	867,8	939,4
10mm sieved fraction	1.214,3	1.353,4	1.508,3	1.664,8	1.837,6	2.028,2	2.195,4	2.376,4
Total	**25.784,9**	**28.737,3**	**32.027,8**	**35.351,0**	**39.019,1**	**43.067,7**	**46.617,9**	**50.460,7**

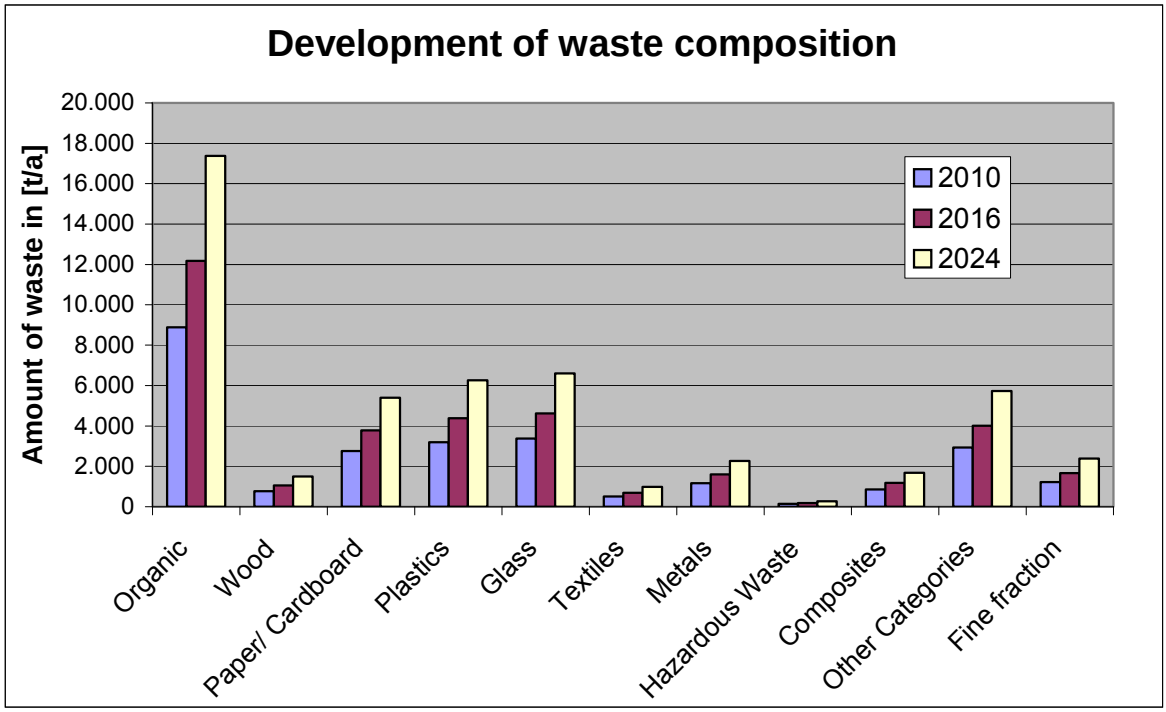

figure 8: Development of MSW composition in Khanty-Mansiysk from 2010 to 2024

For determining waste treatment facilities, further waste properties such as the content of water, the heating value or the potential for incineration, recycling and biological treatment

are of great assistance. In the framework of the waste analysis the water content was measured. Therefore sub-samples from each material fraction (sorted at the waste analysis) were taken and analysed. Based on the results of the water content analysis and literature figures for the calorific values of the material fractions, the heating values of MSW and its fractions were calculated. As shown in table 4 the water content for MSW is 40.6% and the heating value was calculated by 7,000 KJ/kg. MSW with a heating value of 7,000 KJ/kg can be incinerated without supplementary firing.

table 4: Average water content and heating value of municipal waste analysed in Khanty-Mansiysk[26]

1st category	No.	composition [%]	water content [%]	hydrogen content [%]	calorific value Ho(wf) [KJ/kg]	Heating value Hu(roh) [KJ/kg]
Organic	1	34	68.7	3.76[1]	13,580[1]	2,315
Wood	2	3	27.7	6.8[3]	20,630[3]	13,159
Paper/ Cardboard	3	11	14.9	5.12[1]	16,290[1]	12,542
Plastics	4	12	29.9	14.5[3]	38,580[3]	24,082
Glass	5	13	2.0	0.0	0	-49
Textiles	6	2	27.0	6.4[3]	19,900[3]	12,842
Metals	7	5	11.9	0.0%	0	-290
Hazardous Waste	8	1	9.9	0.0%	0	-242
Composites	9	3	12.9	9.8[2]	27,435[2]	21,704
Other Categories	10	11	61.8	1.4[1]	14,000[2]	3,723
Fine fraction	11	5	43.5	1.8	8,000[2]	3,235
Total		**100**	**40.6**	**4.53%**	**15,073**	**6,958**

The potential for incineration, recycling and biological waste treatment was calculated from the waste composition and is shown in figure 9 to 11. As can be seen from these figures, the composition of MSW in Khanty-Mansiysk does not indicate a preferable treatment option (incineration, recycling or biological treatment). The potential for recycling is about 47%, for biological treatment 46% and for incineration about 36%. Including the category organic from kitchen and canteen, the potential for incineration will rise up to 67%. But this means, that the heating value will be reduced to < 10,000 kJ per kg (not suitable for RDF).

[26] [1] - Greiner, et al., 1983; [2] – ARGUS e.V., experienced data; [3] - Bilitewski, et al., 1990

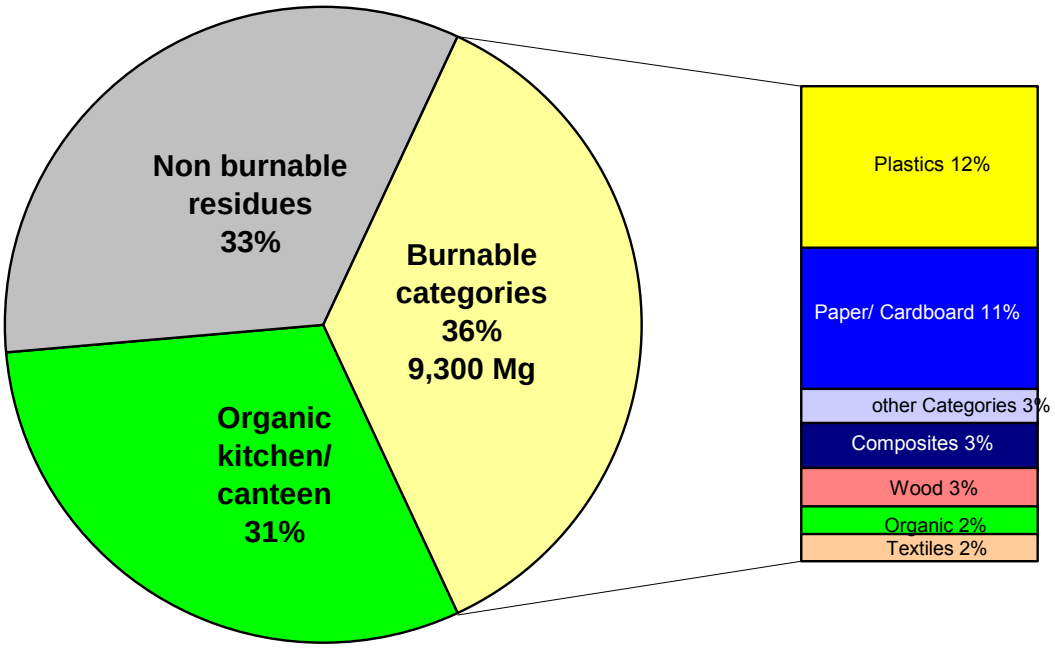

figure 9: Potential for incineration from municipal solid waste in KM municipality

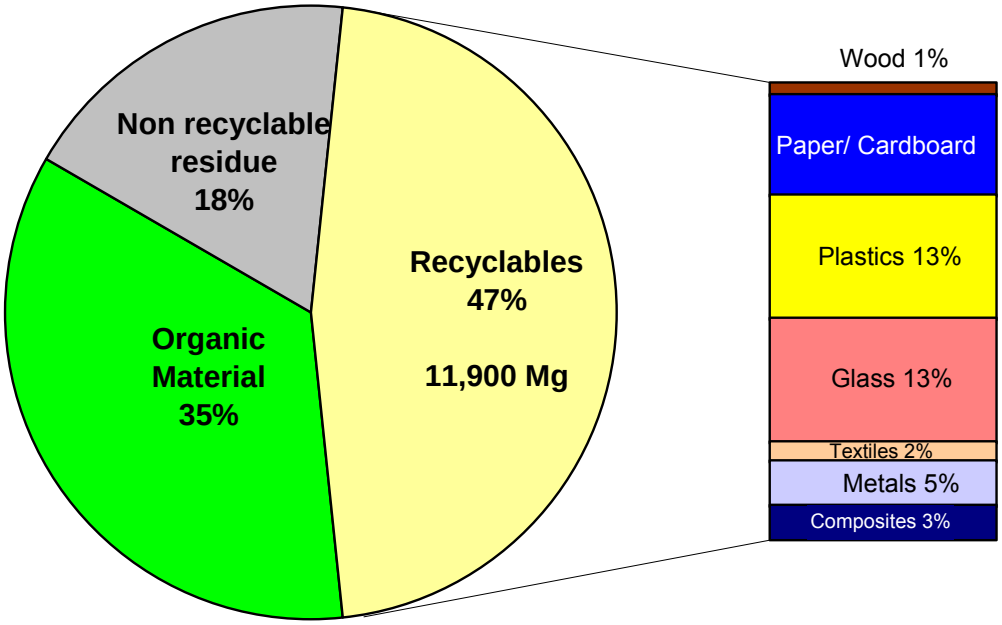

figure 10: Recycling potential from municipal solid waste in KM municipality

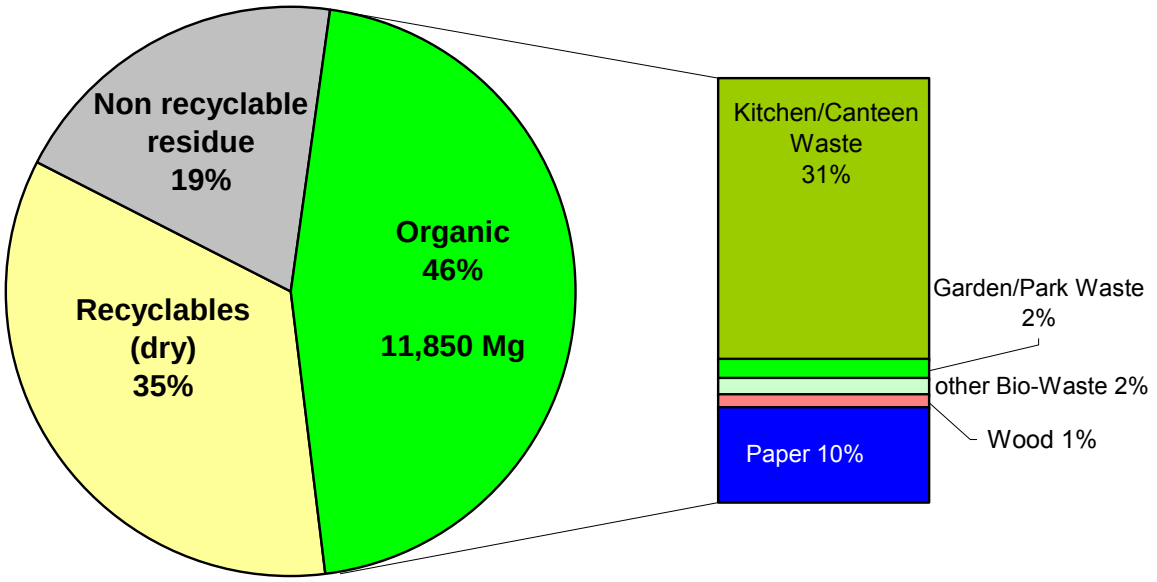

figure 11: Potential or biological treatment from municipal solid waste in KM municipality

Besides the total generated waste stream and its qualities, it is also of great importance, that the expected waste flows, which have to be collected and treated at different stages of the waste management process, are available. For that reason, quotas for separate collection and recycling and recovery rates has to be determined. The table 5 gives the expected figures.

Based on the quotas for prevention, collection, recycling and recovery, the waste flows from the generator to the final recycling, recovery or disposal can be estimated. The waste flows can be taken from figure 12 to figure 14 for the year 2016 and 2024.

table 5: Quotas for prevention, separate collection, recycling and recovery

Waste management type		2012	2016	2024
prevention	all fractions		3%	5%
separate collection	metal	10%	30%	50%
	paper	10%	40%	60%
	glass		40%	60%
	plastics		25%	40%
recycling MBT	metal		85%	85%
	paper		0%	0%
	glass		15%	30%
	plastics		15%	20%
recovery MBT (RDF)	organic citchen		85%	85%
	organic garden		95%	95%
	wood		95%	95%
	paper/plastics		75%	75%
	textiles		95%	95%
	composites		75%	75%

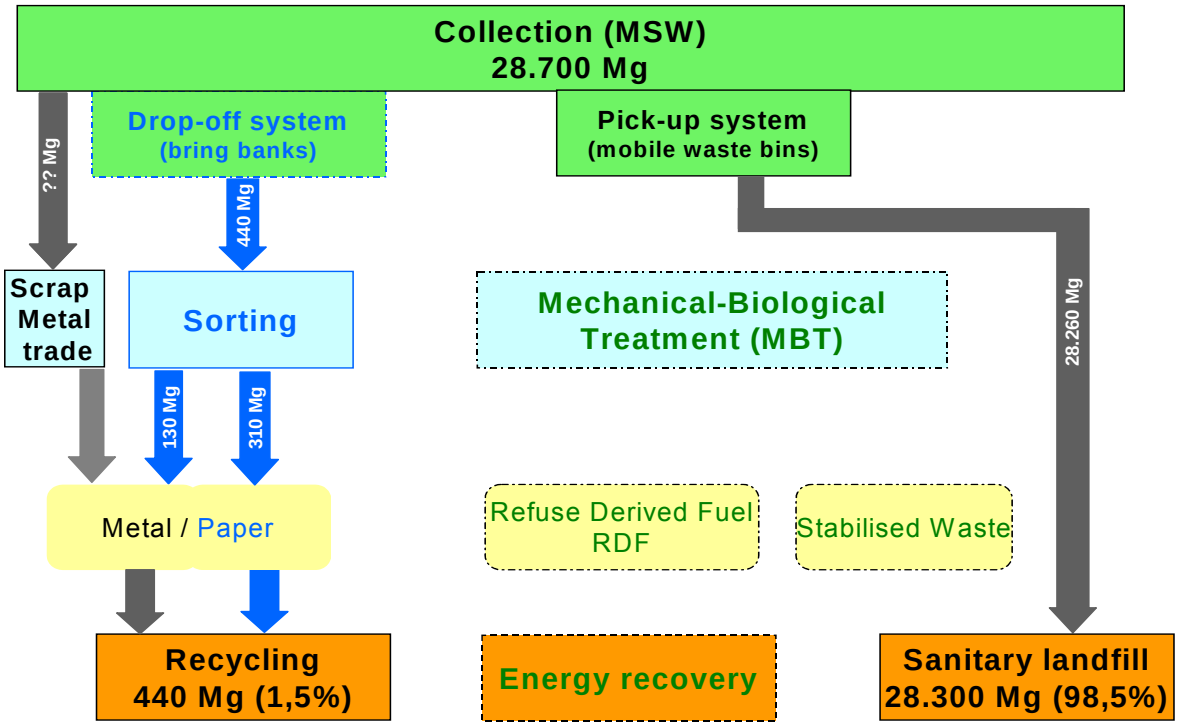

figure 12: Estimated waste flow from generation to recovery/ disposal for the year 2012

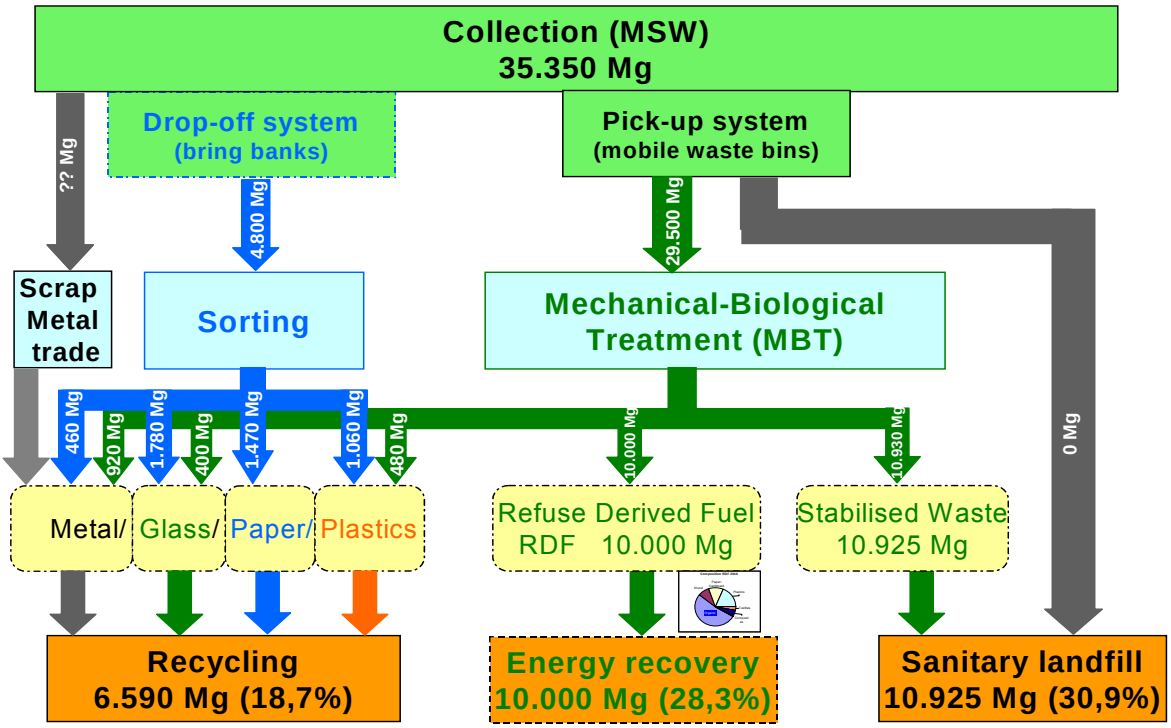

figure 13: Estimated waste flow from generation to recovery/ disposal for the year 2016

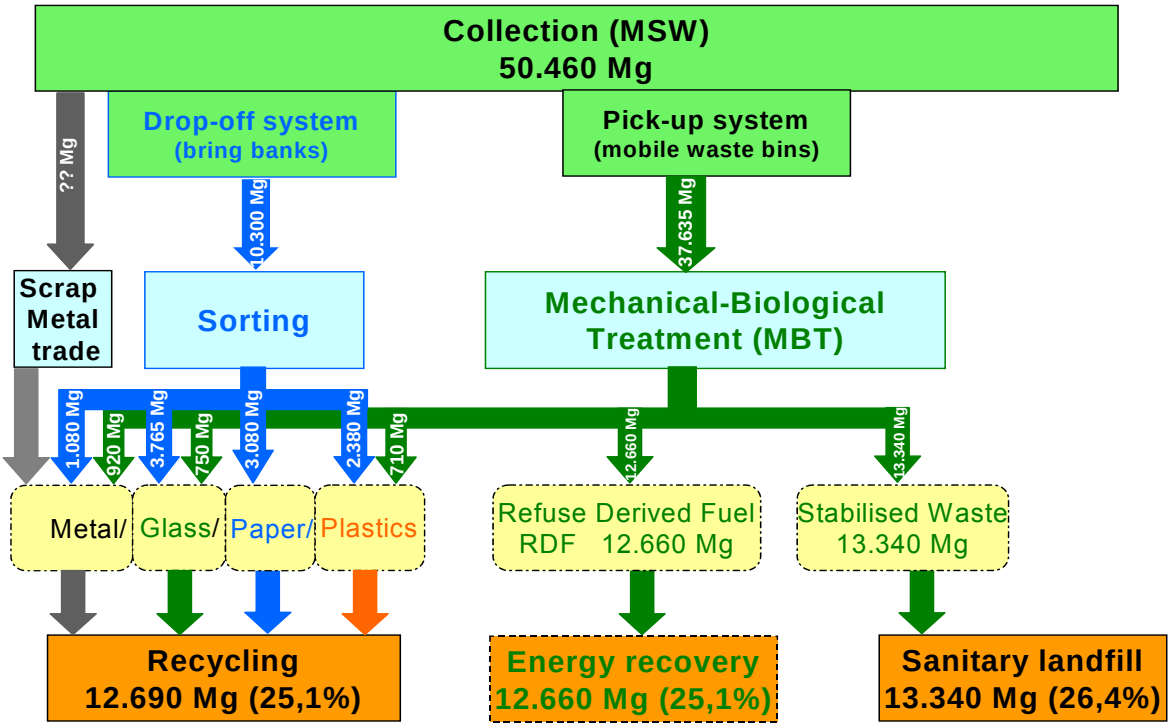

figure 14: Estimated waste flow from generation to recovery/ disposal for the year 2024

Summary of waste flow characterisation

It can be stated that the organic fraction is the biggest waste category in Khanty-Mansiysk with 34%. Nevertheless, the municipal solid waste having a heating value of 7,000 kJ/kg is burnable without supplementary firing. It can be expected, that the heating value will increase due to consumer habits (more paper and plastics, less organic and glass). Furthermore, 36% of the MSW is suitable for the production of **R**efuse **D**erived **F**uel (RDF). During the exclusive incineration of the 36% suitable fractions (paper, plastics, textiles, composites etc.), an increase of the heating value from 7.000 KJ/kg to 16,200 kJ/kg can be assumed. The composition of waste also shows a high potential for recycling and/ or composting as 47% of MSW is recyclable or 46% of MSW is compostable. An in-depth analysis of the MSW from Khanty-Mansiysk regarding its suitability for different waste treatment options was carried out and described in ***Annex III***. In conclusion, it can be stated, that the MSW is suitable for recycling options, for incineration and for biological treatment.

2.1.4 Waste management technologies

Basically waste management can be categorised into three process phases (waste collection & transport, waste treatment and recovery & disposal).

Waste collection can be implemented by a pick-up system, which means, that the waste is collected at each estate, or by a drop-off system, which means, that the citizens will bring the waste to a certain place (e.g. bring banks or recycling centres).

Waste treatment means, that the waste is processed mechanically, biologically or thermal before the residues are brought to a landfill site. Waste treatment serves several purposes: reduction of landfill volume, reduction of carbon emission, reduction of human pathogens, production of recyclables, production of energy.

At the third stage the waste will be recovered (recycled or converted into energy) or disposed. For recycling of materials as glass, paper, metals, plastics etc. a functioning recycling industry has to be established.

Starting with this basic treatment option, multiple variants how to organize the waste management system can be derived. A detailed description of the waste management technologies regarding to their fundamental operating principle, fields of application, reliability, costs and references from plant manufacturers etc. is given in ***Annex II*** to this report.

The following table 6 categorises the basic waste management processes and treatment options.

table 6: Overview on basic waste management processes and treatment options

Process	Sub area	Specification
Waste collection & transport	Pick-up system	Mobile waste container & rear-end vehicle
	Drop-off system	Bring bank & collection vehicle with crane
Waste treatment	Mechanical Mechanical-biological	Comminution, sorting, classification, ...
	Biological	Composting, anaerobic digestion
	Physical	Neutralisation, Sterilisation, Pyrolysis
	Thermal	Incineration
Recovery & disposal	Recovery	Recycling of metals, paper, glass, plastics
		Energy recovery by co-incineration
	Deposition	Inert landfill, sanitary landfill, hazardous landfill

2.1.5 Market opportunities for recycling products

For implementing a new waste management concept, knowledge about the current recycling market is essential. Therefore, a market analysis was implemented during the research for the status-quo-report.

Methodology

In order to implement the market analysis, contact data of recycling companies had to be collected. For identifying these contact addresses the “German Trade and Invest”, the “Russian Chamber of Commercial and Industry”, “Territorial institution of the federal office for state statistic in KMAO-Ugra” and “Territorial Management of Federal Service for supervision in the sphere of nature management in KMAO-Ugra (Rosprirodnazor)” were contacted. Furthermore, internet researches were carried out.

For implementing the market analysis, the recycling companies were called at first and asked to fill in a questionnaire and send it back via email or fax.

The same procedure for implementing the market analysis was applied to recycling companies in Irkutsk, Perm and Yekaterinburg. The contact data of companies in Irkutsk was acquired from the “calendar of waste” (a booklet of recycling companies in Irkutsk) developed within the project “Development of a Waste Management Concept for the Tourist Regions of Lake Baikal”.

For the market analysis three types of companies were identified which play an essential role for waste recycling:

- Companies which collect and/ or treat materials recovered from solid municipal waste such as recycling companies
- Factories which use materials from waste in order to produce new products such as a glass manufacturing company and
- Transport companies for transport of recyclables and waste.

Results

In total, 26 companies were contacted in Irkutsk. One company “Mitugin” which collects, transports and treats end-of life tyres, polymer products and several more recyclable materials responded from Irkutsk. They mainly operate in the region around Irkutsk and produce approximately 25 Mg materials from the (recyclable) waste they collect. Information about what exactly they produce was not provided.

The glass factory “Fabrikant” is located in Surgut and uses raw glass to produce of glass for windows and other glass products. They have an interest to use recycled glass but it must be of good quality. A standard could not be given.

The metal-producing factory “Metallexpo” is also situated in Surgut. It already uses metal from the solid municipal and industrial waste. Figures how many Mg of metal they take out of the waste or need or how many Mg of metal they produce per month/years were not provided.

The company, „Vtortschermet” from Surgut treats used metal and transports it to metal factories all over Russia. Approximately two thousand Mg per year are treated according to the standard “GOST 5787”.

"Ekobalance" collects cardboard and paper in Khanty-Mansiysk and transports the material to Perm, Yekaterinburg for recycling, mostly for toilet paper and tissues. Several dozen Mg of paper/ cardboard are collected per month (a detailed number of Mg can not be given caused by data protection). The standard "GOST 10700-97" has to be taken into account for collecting carton and paper for a further treatment.

Transport companies could not be identified during the research for the market analysis. Many companies which collect the material from the waste also transport the waste to the treatment plant/ factory – compare the companies "Ekobalance" from Khanty-Mansiysk and "Mitugin" from Irkutsk.

According to answers of the waste experts the recycling market in KMAO-Ugra is more or less determined by the (very) small companies. At the moment, there are hardly figures to estimate the quota of the recycling market in detail. Approximately, 1-2% recycling of solid municipal waste can be estimated currently, mainly the materials "metal" and "cardboard/ paper" from MSW.

One percent as recycling quota of solid household waste is estimated for the Irkutsk region. Mainly glass, cardboard/paper, metals and end-of-life tyres are recycled. Two to three as recycling quota is estimated for the region of Perm; mainly metal, glass and cardboard/paper is used for recycling.

Summary of results from the market analysis

Although the market analysis does not provide quantitative results it provides other information that is valuable for the development of an urban waste management concept for KM municipality:

- There are already companies which collect different materials from of the waste; mostly cardboard, metal and end-of-life tyres.
- The current quota of recycling is very small; only few and small companies exist to carry out the collection of different waste streams. However, these companies are also very interested in developing this branch.
- There is an interest of manufacturing companies to obtain recyclable materials as a resource for making their products.
- The regional administration and the High Technology Park have an interest in establishing a recycling market and support the development with their resources. The Department of Ecology of KMAO-Ugra estimated that recycling can be built up to 15%[27]. The main emphasis is on glass, plastic and cardboard.
- At the moment there is no waste treatment facility in KMAO-Ugra – except a company treating metals in Surgut. Nevertheless, the High Technology Park was asked by investor to support the implementation of a sorting plant in Surgut and different requests from investors for investment into waste treatment facilities to the Department of Ecology. Furthermore, there are plans to build a treatment facility for end-of-life tyres close to

[27] Vaschenko, P., 2011, interview, Department Ecology of KMAO-Ugra [22.06.2011]

Surgut. That also demonstrates that there is an interest in developing the recycling industry.

- That also means that Surgut has to be considered as a recycling centre in the framework of the development of the waste management concept for Khanty-Mansiysk. Surgut is 250 km far away from Khanty-Mansiysk; i.e. long distances between Khanty-Mansiysk and Surgut have to be taken into account.
- Because Khanty-Mansiysk is an administrational town there is a high potential for cardboard and paper recycling. According to Mr Ilchuzhin *(Head of "Ekobalance")*, a lot of papers produced by the administration are burnt for data protection reasons. However, a systematic collection of cardboard is desirable.
- In Khanty-Mansiysk, there are three companies which collect recyclable materials from waste: "Ekobalance" – which collects cardboard, and "Akkumulatornoi Dom" – which collects metal, and "Berejosow" – which collects end-of life tyres. At the moment there are no detailed data for the latter both companies.

The existence of a recycling market is a crucial prerequisite for implementing recycling strategies in KM municipality. Currently, the recycling market hardly exists and is mainly implemented by very small companies. This fact has to be taken into account for developing the waste management concept.

2.1.6 Legal requirements

The research regarding waste legislation demonstrates that the waste legislation in Russia places fundamental requirements on waste management. Nevertheless, these requirements have not been implemented yet. Many laws were developed at the time of the Soviet Union and do not correspond with European standard.

The development of a waste management concept for KM municipality depends on the requirements that are given by Russian legislation. Regarding waste legislation, the main questions for developing an urban waste management concept raised here are:

- What are the objectives of waste legislation and what is the relevant legislation on federal level in Russia and in KMAO-Ugra?
- Which terms, definitions, classification and standards exist to describe the different waste streams?
- Who is authorized to collect the waste and who is the waste holder?
- What kind of fee systems exists; i.e. who has to pay for what?
- Which are the competent authorities to develop and work on (urban) waste management concepts on federal and local level?

Besides providing hygienic conditions in towns and settlements (compare *SanPiN 42-128-4690-88*[28]), environmental protection is the main objective for dealing with waste within the

[28] SanPiN 42-128-4690-88 "Sanitary Regulations for the content of populated areas", from 05.August 1988

Russian legislation. For that reason, the *Constitution of the Russian Federation*[29], according to article 42, includes that each person has the right to an intact environment, the right to information about the current state of the environment as well as the right to compensation if there are law violations which cause problems with health or properties.

In addition, the *Federal Law on industrial and municipal waste No. 89*[30] describes the objectives of the Russian waste legislation and corresponds with the key act regarding waste management in Russia. The law defines the legal basis of dealing with industrial and municipal waste in Russia. The major aims of this law are to prevent negative impacts on the health of humans and the environment caused by incorrect waste disposal as well as to implement the recycling of materials from waste as a source for commodity and economic revenues.

The law also defines municipal and industrial waste as stocks of raw materials, intermediate products, other goods or products which are formed during production or consumption, as well as goods (products) that have lost their consumer properties. Furthermore, it subdivides waste into municipal waste and industrial waste. Municipal and industrial wastes have to be classified according to their negative impact on the environment.

The ownership of waste is defined in this law as well. The ownership of the waste belongs to the owner of the raw materials, intermediate goods, products or other products and goods as a result of which the waste is formed. This means that the tenants are the owners of the waste they produce. In this case, the *Civil Code of the Russian Federation N 51-FL*[31] stipulates that by disposing their property, a person waives the right to its ownership. It also states that a person in ownership, possession or use of land, water body or other object, which are abandoned industrial wastes and other wastes (including municipal solid waste of the population), is entitled to take these things on their property, to start using or treating them. Consequently, the owner of this site (usually the municipalities/ local administration) has the right to take the waste into their property.

The *Federal Law on industrial and municipal waste No. 89*[32], Article 20, also includes a waste cadastre. The cadastre is described in detail in *The determination of the federal cadastre of waste N 786*[33], which contains 114 waste types with reference to one of the five hazardous waste classes. The governments of Russian administrative regions, such as the government of the Khanty-Mansiysk Autonomous Okrug – Ugra, have the option to develop and manage a regional waste cadastre based on the federal cadastre. Therefore, a regional cadastre[34] was developed by the Government of KMAO-Ugra. The regional cadastre of KMAO-Ugra also includes the 114 federal groups, which are obligatory for each regional cadastre, and it is extended by several sub-groups for special waste from the oil and gas industry and snow as waste.

[29] Constitution of the Russian Federation, 12.December 1993 (last update 30.December 2008)
[30] Federal Law on industrial and municipal waste, 24.June 1998 No. 89 (last update 30. December 2008, No. 309-FL)
[31] Civil Code of the Russian Federation, 30. November 1994, N 51-FL (last update 18.07.2009 N 181-FL)
[32] Federal Law on industrial and municipal waste 24.June 1998 No. 89 (last update 30. December 2008, N 309-FL)
[33] The determination of the federal cadastre of waste, from 2.December 2002 N 786 (last update 30. July 2003)
[34] Government of Khanty-Mansiysk Autonomous Okrug – Ugra, Regulation of the correct order of the Government in the Khanty-Mansiysk Autonomous Okrug – Ugra, 29. November 2007 N 294-p - "Regulation of the management of the regional register of waste", 2. April 2011, N 95-p

According to the *Housing Code of the Russian Federation N 188-FL*[35], the collection and transportation of MSW is not a responsibility of the public services. A charge for the collection and transportation of waste is included in the fee for maintaining common property in an apartment house. In private homes, residents sign an agreement on the collection and disposal of waste, often directly with the refuse collection operator. Usually the payment for waste management is covered by general tax revenues and/or local/municipal revenues as well as state subsidies for local budgets. Local/municipal revenues include the apartment rent or payment obligations from home and building owners. Both (rent and payment obligations) only include a very low waste charge.

In Russia, two federal ministries and three federal services (see figure 15) exist to regulate environmental affairs and they are specially authorized to control the implementation of waste management.

[35] Housing Code of the Russian Federation, 29.December 2004 N 188-FL (last update 30.November 2010, No. 328-FL)

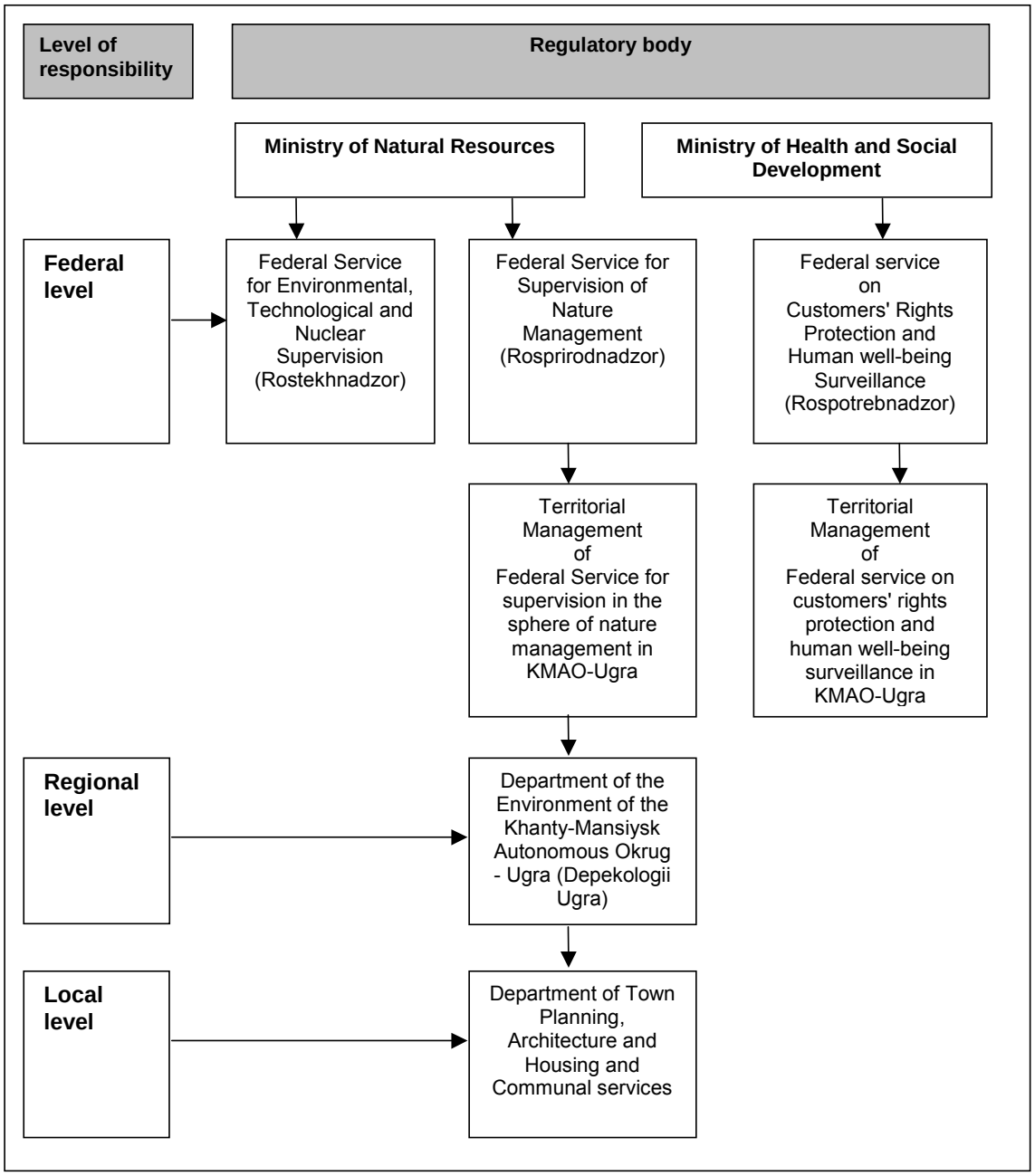

figure 15: Regulatory bodies responsible for waste management on the example KMAO-Ugra and Khanty-Mansiysk

Waste management and disposal is a responsibility of Rosprirodnadzor and Rospotrebnadzor. They correspond to executive bodies for state regulations of waste management; i.e. they accomplish the organisation and realisation of ecological control, they develop laws and norms and co-ordinate with other federal institutions in this area in Russia.

The Federal service on customers' rights protection and human well-being surveillance (Rospotrebnadzor) is in charge of controlling the hygienic conditions in urban areas and settlements. From this service different laws developed such as *Federal Law on the sanitary-*

epidemiological welfare of the population No 52-FL[36] and sanitary rules such as *SanPiN 42-128-4690-88 "Sanitary Regulations for the content of populated areas*[37].

The Federal Service for supervision of nature management (Rosprirodnadzor) has to control the implementation of ecological protection during the process of waste treatment and waste disposal.

Both Rospotrebnadzor and Rosprirodnadzor are further subdivided into Territorial Managements such as Territorial Management of Federal Service for supervision of nature management in KMAO-Ugra and Territorial Management Federal service on customers' rights protection and human well-being surveillance in KMAO-Ugra. These Territorial Management Services are mainly responsible for implementing laws, acts etc. in the region/ territory of their duty.

The Federal Service for Environmental, Technological and Nuclear Supervision (Rostekhnadzor) had the task of waste management and disposal until 2009; currently it has the responsibility for controlling of waste from nuclear power stations.

For implementing waste management concepts in KMAO-Ugra, there are three regulatory bodies on different state levels responsible with different duties (see figure 15).

The ***Federal Service for Supervision of Natural Resources (Rosprirodnadzor) in the Khanty - Mansiysk Autonomous Okrug – Ugra*** controls and supervises compliance with the environmental protection legislation of the Russian Federation, including air protection and waste policies (except radioactive waste). It also organises and conducts the state environmental review at the federal level in accordance with the legislation of the Russian Federation. The Federal Service is responsible to permit the transboundary movement of wastes, ozone depleting substances and products as well as the establishment of waste disposal facilities within its jurisdiction. Furthermore, it co-ordinates the work on maintaining the state cadastre of waste and public records in waste management as well as check out the validity of established classification of hazardous wastes to the environment. Finally, it allocates licenses to legal entities and individual entrepreneurs engaged in the same kind of economic or other activities to collect, use, disposal, transportation and waste disposal of I-IV risk classes. Parallel, Rosprirodnadzor in the Khanty - Mansiysk Autonomous Okrug – Ugra represents the interface between the federal level and administrative regions of the Federation of Russia.

The ***Department of the Environment of the Khanty-Mansiysk Autonomous Okrug - Ugra (Depekologii Ugra)*** performs the functions of implementing the unified state policy, legal regulation and the provision of public services in the field of industrial and municipal waste. In addition, it participates in federal and regional programs in the field of waste management and provides public information about environmental conditions in the autonomous region, including in waste management. The department also maintains a regional cadastre which includes the regional waste catalogue, and a list of places where landfills are and a data bank about which technology is used in the region.

[36] Federal Law on the sanitary-epidemiological welfare of the population, 30.March 1999, No 52-FL (last update 28.September 2010, No.243-FL)

[37] SanPiN 42-128-4690-88 "Sanitary Regulations for the content of populated areas", 05.August 1988

The ***Department of town planning, architecture and housing and communal services*** is responsible for the management of waste generated in KM municipality. In accordance with Paragraph 25, Article 16 of *Federal Law on general principles of organisation of local self-government in Russian Federation No.131*[38] collection, transportation, disposal and recycling of household and industrial waste is a duty of local administration. Different departments are responsible for this duty such as the Department of town planning, architecture and housing and communal services of KM municipality.

Currently, the duty only includes the collection, transportation, and disposal of household and industrial waste; there is no waste recycling program in use in KM municipality.

Summary

The research regarding waste legislation demonstrates that waste legislation in Russia places fundamental requirements such as hygienic conditions and environmental protection on waste management. These legal objectives have to taken into consideration while developing the waste management concept on the one hand.

On the other hand, it can also be stated, that there is no specific waste legislation which regulates responsibilities, management, environmental standards and the inspection and control of landfill sites. However, within the development of a sustainable waste management concept, environmental standards for waste treatment have to be defined.

Furthermore, the Russian legislation doesn't include incentives to reduce waste. For an optimal implementation of the concept, (financial) incentives for the inhabitants to reduce; i.e. to separate, the waste are recommended.

According to the law, the waste management finance system is oriented on the operation cost of flats and an increase depends on the national income system. Usually, the implementation of a new waste management concept is connected with extra costs which need to be covered. Possibilities for financing are the selling of recyclable materials or RDF. The existing market and market price for recycling products and RDF have to be identified.

2.1.7 Regional concept

A regional waste management concept for KMAO-Ugra was developed in 2011. This concept includes the main strategies for dealing with waste and it is valid until 2020. The main objective is the prevention of negative environmental impacts caused by wrong disposal of waste. Therefore, the concept requires a decreasing of waste amount disposed on of landfill sites. Furthermore, the main emphasis regarding waste treatment is on recycling of waste. The regional concept also defines a schedule and a budget for its implementation.

[38] Federal Law on general principles of organisation of local self-government in Russian Federation", No.131-FL

For implementing the regional waste management concept, all settlements of the KMAO-Ugra (about 200) were sub-divided into seven categories according to two main characters:

- number of population and
- its transport availability.

For each category, waste treatment technologies were proposed. The first category includes the six biggest cities of KMAO-Ugra. The aim is to develop these cities to centres of waste recycling for each sub-region of KMAO-Ugra. The seventh category includes the smallest villages without any road connections[39].

Khanty-Mansiysk belongs to Category 1 with the main objective on recycling. Based on this objective for the Category 1, the implementation of the following aims is recommended in the technical report to the regional programme:

- the extension of the current existing landfill to an inter-communal landfill with a total capacity of 846,000 Mg and an area of 8.8ha
- the re-construction of the existing places for landfilling on the waste disposal site (if it is necessary) in consideration of the extension to an inter-communal landfill
- the implementation of treatment plant for shredder the bulky waste on the inter-communal landfill plan
- a sorting plant with a capacity of 33,000 Mg/a including wood chippers
- the collection and recycling of paper and plastic is planned for municipal solid waste treatment in Khanty-Mansiysk.
- The implementation of eight collections points for secondary raw materials and hazardous waste[40].

The following municipalities should also dispose of the solid household waste on the inter-communal landfill site of Khanty-Mansiysk:

- Krasnoleninski,
- Shapsha,
- Elizarovo,
- Batovo,
- Troitza and
- Sogom.

It can be assumed that approximately 1,000 Mg/ a will be disposed on the landfill from these municipalities[41].

[39] The Government of the Khanty-Mansiysk Autonomous Okrug - Ugra, Resolution and Trust Program of the Khanty-Mansiysk Autonomous Okrug - Ugra regarding “The development of waste management system of production and consumption in the Khanty-Mansiysk Autonomous Okrug - Ugra until 2012 - 2015 years and for a period up to 2020, 28. October 2011, N 403-P

[40] Scientific and technical progress report on the development of waste management in Khanty-Mansiysk Autonomous Okrug - Ugra, Volume 3., Justification of the scheme of waste management, Book 1., Organisational and technical measures, St. Petersburg 2011

Furthermore, according to the technical report it is planned to include engineering construction and therefore, a cover and a base sealing system will be developed. The cover sealing system includes the final cover. The base sealing system consists of a 2m level of sand (as the basis below the waste), followed by a clay geo-synthetic barrier („Bentomat"), finally gravel and a drainage will be constructed. In addition, key buildings (such as an office) have to be constructed to guarantee the (economic) functionality of the landfill.

For developing the current landfill site to an inter-communal landfill site is planned (including the re-construction of the landfill) from 2012 until 2014. The budget is 7,171,000 Euros (272,500,000 Roubles). It should be implemented via regional, local administration and private organisations.

The implementation of a shredder for bulky waste is planned in 2014. The budget is 315,790 Euros (12,000,000 Roubles) and should be implemented via regional administration.

The implementation of the sorting plant is planned from 2012 until 2014 and includes a budget of 3,263,160 Euros (124,000,000 Roubles). It should be implemented through the regional, local administration and private organisations.

The wood chippers should be implemented in 2013. The budget is 5,260 Euros (200,000 Roubles). The regional administration of KMAO-Ugra is responsible for the implementation.

The collection and recycling of paper and plastic is planned from 2016 until 2020 and includes a budget of 2,370 Euros (90,000,000 Roubles). For the implementation, the regional administration of KMAO-Ugra is responsible.

The implementation of eight collections points for secondary raw materials and hazardous waste is planned from 2012 until 2015 and includes a budget of 105,260 Euros (4,000,000 Roubles). It should be implemented via regional and local administration.

In total, all features for waste management for the town Khanty-Mansiysk should be carried out ***from 2012 until 2020***. The total recommended budget for the implementation of all features in Khanty-Mansiysk is ***13,228,945 Euros*** (502,700,000 Roubles)[42].

The total budget for implementing the regional concept in KMAO-Ugra until 2020 is approved by the regional government and is ***565,446,000 Euros*** (21,486,977,000 Roubles)[43].

In conclusion, the regional waste management concept will improve the current situation of the waste disposal in an environmental manner until 2020.

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[41] The Government of the Khanty-Mansiysk Autonomous Okrug - Ugra, Order of strategy regarding waste production and consumption in the Khanty-Mansiysk Autonomous Okrug - Ugra until 2020, 3. November 2011, N 625-P

[42] All figures regarding features for the town Khanty-Mansiysk are recommended in: Scientific and technical progress report on the development of waste management in Khanty-Mansiysk Autonomous Okrug - Ugra, Volume 3., Justification of the scheme of waste management, Book 1., Organisational and technical measures, St. Petersburg 2011

[43] Figures are given in: The Government of the Khanty-Mansiysk Autonomous Okrug - Ugra, Resolution and Trust Program of the Khanty-Mansiysk Autonomous Okrug - Ugra regarding "The development of waste management system of production and consumption in the Khanty-Mansiysk Autonomous Okrug - Ugra until 2012 - 2015 years and for a period up to 2020, 28. October 2011, N 403-P

2.2 Technical description of the concept

Waste is generated by different sources (private households, commerce and industry) and can be quite different according to its properties (hazardous, bulky, important in volume, heterogeneous, unmixed etc.). Waste management covers the complete process from waste generation to final recovery or disposal (waste collection & transport, waste treatment and recovery & disposal).

Consequently, the collection, treatment and recovery/disposal of different waste types have to be adapted to each specific waste stream. Industrial waste has to be kept separately from municipal waste, hazardous waste from non-hazardous waste and mainly mineral waste such as construction & demolition waste (important in volume) should be collected, treated and recovered/disposed separately from other waste types. For recycling purposes valuable materials such as paper, glass, metals and plastics should be kept separately as well.

The waste management concept considers the waste types (1) household & commercial waste, (2) bulky waste, (3) construction & demolition waste, (4) street cleaning residues, (5) medical waste, (6) industrial waste and (7) other special waste types such as end-of–life vehicles, end-of-life tyres, batteries & accumulators, waste oil etc. Each waste type can include more or less hazardous components. The waste types (1) to (5) can be united to municipal solid waste. Industrial waste can be defined as production residues which are not similar to household & commercial waste. Industrial waste is often hazardous and mainly homogeneous. In KM municipality industrial waste is not distinguished from MSW, either in the collection nor in the disposal phase. Although it can be assumed, that industrial waste is not generated in significant quantities it should be collected and disposed separately from MSW.

In the framework of the project mainly household & commercial waste was analysed. The proposed treatment, recycling and disposal technologies focus on this main waste stream. For proper waste treatment options for construction & demolition waste or industrial waste these waste streams has to be further investigated. The waste management concept has to be projected forward for these waste types.

Hazardous and non-hazardous waste has to be kept separate by the waste generator. The collection, treatment and disposal of hazardous and non-hazardous waste have to be organised separate as well. For waste flows important in volume such as construction and demolition waste or other mass waste streams from the industry it could be advantageous to keep these waste types separate from MSW. This means, that the landfill site has not to meet the highest standards for all types of waste. According to the potential risk of different waste types at least three classes of landfills can be distinguished (sanitary landfill site, hazardous waste landfill and inert landfill) and should be considered in the WMC. Recyclables should also be kept separate at source and collected in specific containers provided for this purpose. Alternatively recyclables can be gained by waste treatment such as MBT. But the collection of recyclables along with residual waste will reduce the quality of those recyclables significantly.

The schematic illustration given in figure 16 shows the proposed waste management concept for Khanty-Mansiysk.

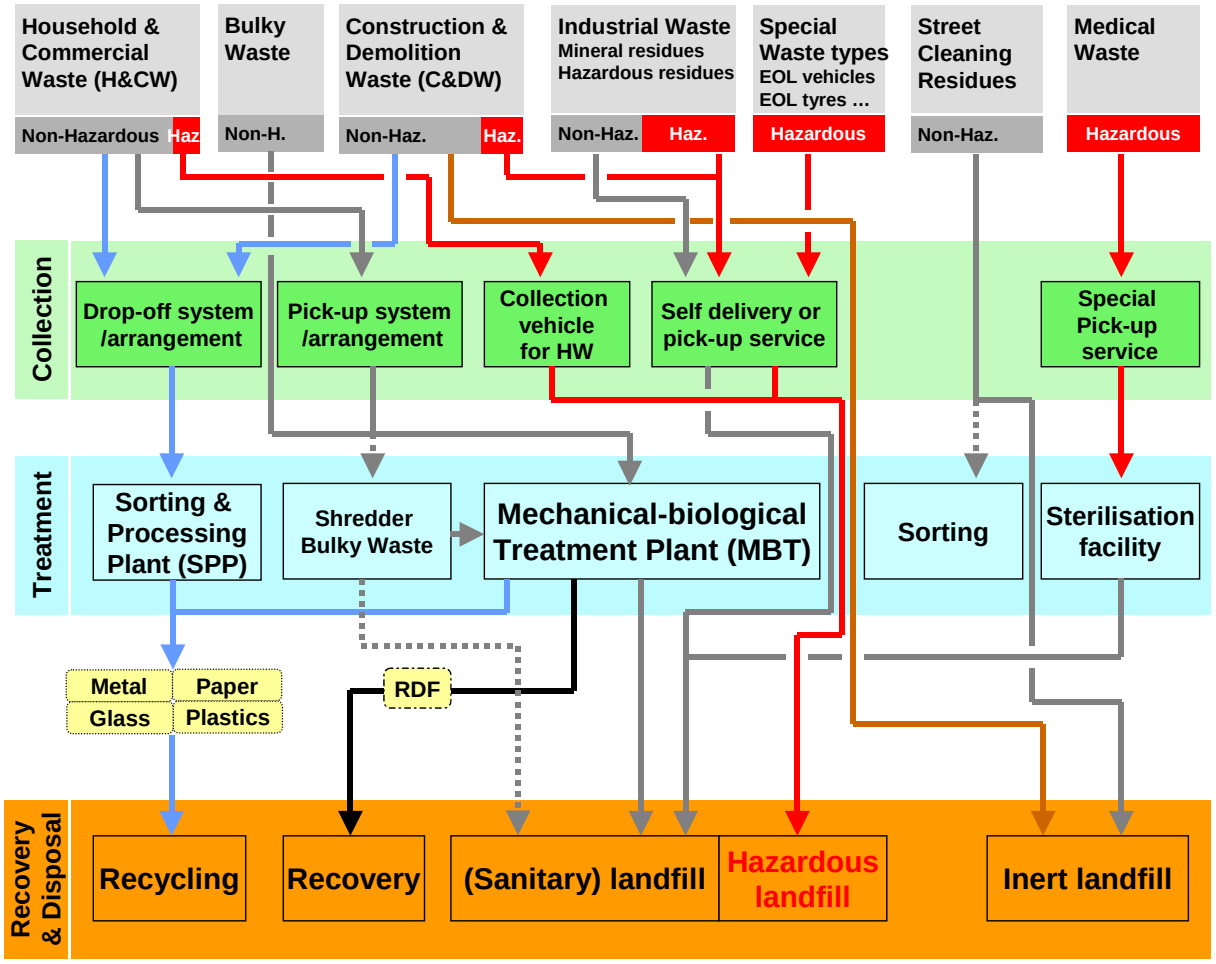

figure 16: Illustration of waste management concept

2.2.1 Waste collection & transport

The WMC proposes to collect different waste streams from private households, commerce and industry.

- Household & commercial waste
  - Residual waste from households and commerce
  - Recyclables from households and commerce
  - Hazardous waste from households and commerce
- Bulky waste
- Construction & demolition waste
  - Residual waste from construction & demolition activities
  - Recyclables from construction & demolition activities
  - Hazardous waste from construction & demolition activities

- Industrial waste
  - Hazardous residues from production
  - Non-Hazardous residues from production
- Street cleaning residues
- Medical waste
- Other special waste types

Residual waste from households and commerce will be collected by a pick-up system, which means, that the waste is collected at each estate. This can be organised by using and possibly improving the existing waste collection system. It is recommended to replace the current 500 litre container (mainly without cover) by modern container with wheels and cover and volume of 1,100 litre. These containers are then picked up by refuse collection vehicles, which are in most cases of rear end loaded. As far as possible each real property should have their own container location and number of container according to the people living in the buildings.

The recyclables paper, glass, metals and plastics should be collected separately at source by a drop-off system, which means, that the citizens will bring the waste to a certain place (e.g. bring banks or recycling centres). In the drop-off system, accumulated waste amounts are taken by the waste generator to a central location and are being dropped there into specially set up containers. Collection vehicles need to go to these central sites only to pick up the waste. Collecting waste in this way is most suitable for source separated recyclables. Additional the municipality should implement a centrally located recycling centre where private persons and small businesses can also bring their recyclables.

Hazardous waste from private households should be collected by the municipality at regular intervals. After an announcement of the collection of hazardous waste in local information services a specific vehicle drive from door to door and collect hazardous waste such as batteries, waste oil, waste paint and varnish containing organic solvents or other dangerous substances, chemicals, drugs etc. two or four times a year. Additional the municipality should implement a centrally located recycling centre where private persons and small businesses can also bring their hazardous waste.

Bulky waste should be collected separately from household & commercial waste because of the size of the constituents which will not fit into regular waste bins of the pick-up system. It can be collected in regular intervals by specific vehicles. This measure will avoid the contamination of the container sites.

Construction & demolition waste should also be separated from residual waste from household & commerce. The collection of these waste types could be offered by public or licensed private waste management companies. It is recommended to dispose these non-hazardous waste streams on inert landfill sites. For this, valuable landfill volume can be saved. The recyclables from construction & demolition activities can be separately collected by the drop-off system. Hazardous waste from construction & demolition activities has to be kept separately at source and transported by public or licensed private waste management companies.

Industrial waste should be at least kept separately into hazardous and non-hazardous categories. Industrial waste should be excluded from being dropped into the containers for residual waste from household & commerce. That means, that the owners of hazardous waste has to be forced by law to keep hazardous waste separate at source and either to transport the waste to the landfill by themselves or to contract a waste management company. The municipality should ensure, that hazardous waste is stored at certain and save area on the landfill site or is transported to the next hazardous waste landfill. Industrial companies should classify and declare their waste according to the waste cadastre of KMAO-Ugra.

Street cleaning residues is collected by specific vehicles and includes garden & park waste and market waste. This waste type is carried untreated to the landfill site.

Medical waste is collected separately from MSW at source and treated in a sterilisation plant before disposal.

Other special waste types namely Eol tyres, Eol vehicles, batteries & accumulators, waste oil etc. should be kept separately at source and collected by specific vehicles. Alternatively a collection point (e. g. recycling centre) should be established, where these waste types can be delivered by the generator or contracted transport companies.

From figure 5 (see page 14) it can be seen, that some types of hazardous waste (e. g. hospital waste) are already collected separately and treated (sterilised), on the other hand hazardous waste from industry and private households/ small businesses is still disposed together with MSW. For these hazardous waste types either collection schemes or treatment or disposal options are implemented. In the short term specific protected areas on the production sites and/ or the landfill site should be prepared to deposit (intermediate) these hazardous substances until a final and sustainable solution is realised.

2.2.2 Waste treatment

Waste treatment means, that the waste is processed mechanically, biologically or thermal before the residues are brought to recycling facilities or to a landfill site. Waste treatment serves several purposes: reduction of landfill volume, reduction of carbon emission, reduction of human pathogens, production of recyclables and production of energy.

The WMC focuses on Municipal Solid Waste. Therefore the treatment options for hazardous waste and waste important in volume are not addressed in the framework of this concept. Two treatment facilities for the processing of MSW are recommended. For the processing of the separate collected recyclables a SPP for paper, glass, metals and plastics is proposed. For the processing of the residual waste, a mechanical-biological treatment plant (MBT) is recommended. In order to exploit synergies both facilities should be located near by. A recycling centre consisting out of the sorting and processing facility, the MBT plant and other waste related activities such as shredding bulky waste, collection point for hazardous waste, processing of construction & demolition waste etc. could be implemented. It is also considerable to build these plants on or near by the landfill site. Anyway it should be considered, that the transport routes to deliver the waste to the recycling centre and to carry the recyclables from the location to the recycling industry should be appropriate.

Sorting and processing plant (SPP)

For the further processing of the separate collected recyclables we propose to build a sorting and processing plant (refer to assessment of scenarios in ***Annex III*** or this report). The facility is a factory building where the collected materials are stored intermediately and processed for further recycling activities. Paper has to be separated into defined categories (paper quality) freed from contaminating substances and pressed into transportable bales. Glass has to be washed, sorted by colour and released from impurities (especially from metals). Metals have to be shredded, cleaned by removing disturbing and contaminating substances and sorted into ferrous and different kinds of non-ferrous metals. For transportation metals have to be pressed into bales. The processing of plastics is most challenging. Different types of plastics (e. g. PE, PP, PS, PVC etc) has to be sorted automatically (float-sink plant, air separator, etc.) or manually by hand-sorting on a conveyer belt. The separated plastic fractions must be comminuted, washed, removed from impurities, dried, fabricated and filled into bags. An example for a sorting and processing plant is given in figure 17. The detailed description of the processing technologies is listed in ***Annex II*** to this report.

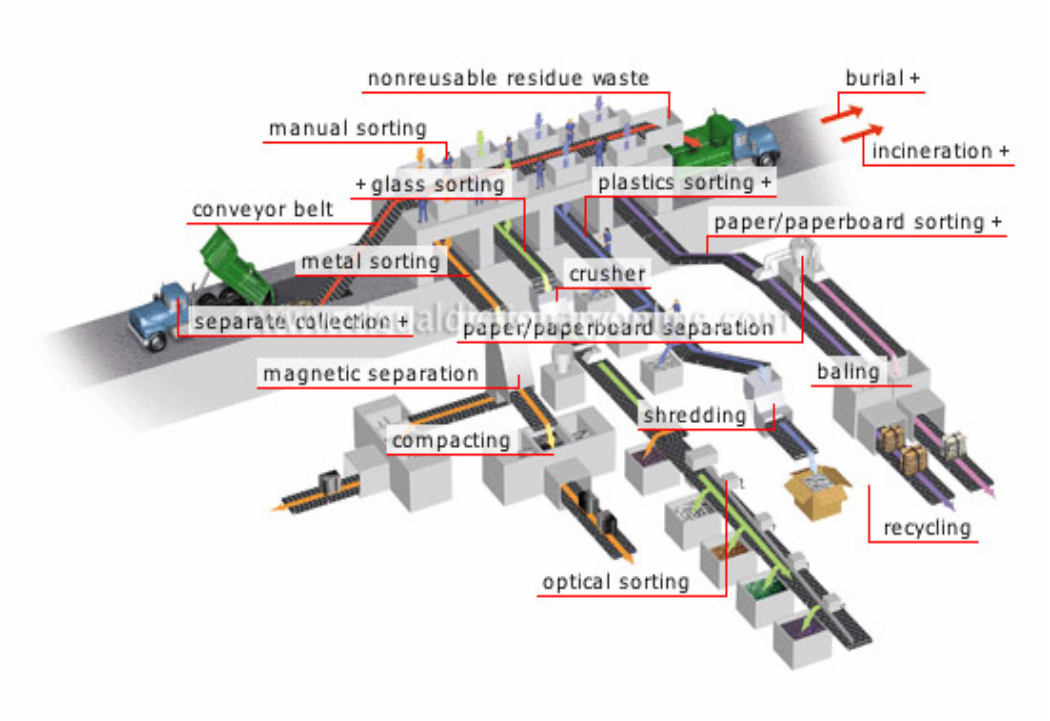

figure 17: Sorting plant (http://visual.merriam-webster.com)

Mechanical-biological treatment plant (MBT)

Mechanical biological waste treatment shall achieve:

- a stabilisation and reduction of the risk potential together with a significant mass and volume loss through biological decomposition which could count towards the diversion of biodegradable waste from landfill, and in conjunction therewith
- the processing of the waste in order to generate separate material streams and improve suitability for subsequent treatment processes and
- the recovery of recyclable materials.

To process MSW from households and commerce the construction and implementation of a mechanical-biological treatment plant (MBT) is recommended (refer to assessment of scenarios in ***Annex III*** or this report). In the MBT the waste is treated by a combination of mechanical and biological processes (see figure 18) with the goal of reducing overall mass and volume and achieve the stabilisation of the waste before its final disposal. During the treatment recyclable materials (mainly metals) and a combustible fraction are separated from the remaining waste stream by mechanical processes, while rotting processes achieve the drying and degradation of the waste material and thus its deactivation.

The possible process configurations in MBT plants are numerous although consisting always of mechanical processes and a core biological treatment. With rising environmental standards and higher recycling requirements, integrated systems have been developed that combine the two technology stages as an integrated entity and include emissions and odour control facets within a closed cycle. They can offer a reasonably flexible approach to the management of MSW due to their high tolerance of variation in waste composition and can even function without any additional collection infrastructure, means they are also suited to the un-separated H&CW stream. Additionally glass, paper and plastics can be collected separately by drop-off systems and pre-treated (sorting).

In the given example the MSW (see figure 18) is firstly crushed to a size smaller than 200 mm and afterwards the MSW is put into rotting boxes. There the organic fraction is digested and at once the remains are biologically dried. The exhaust air which is generated from the biological process is cleaned in bio-filters or air-washers. The accumulated condensate passes through a condensate cleaning process, whereas the clean water can be used for cooling towers. Then, when the waste is dry (rotting duration depends on the system used), density separation takes place by air classifiers, whereat light and heavy fractions are separated. Both the light weight and the heavy weight fraction are going further through metal separators (eddy-current separators and magnetic separator systems). There recyclable metals are cut out for further use. The non combustible remains from the heavy weight fraction are going to be landfilled. After the recyclable plastics are extracted, the conditioned combustible light weight fraction can be used as RDF in industrial energy recovery.

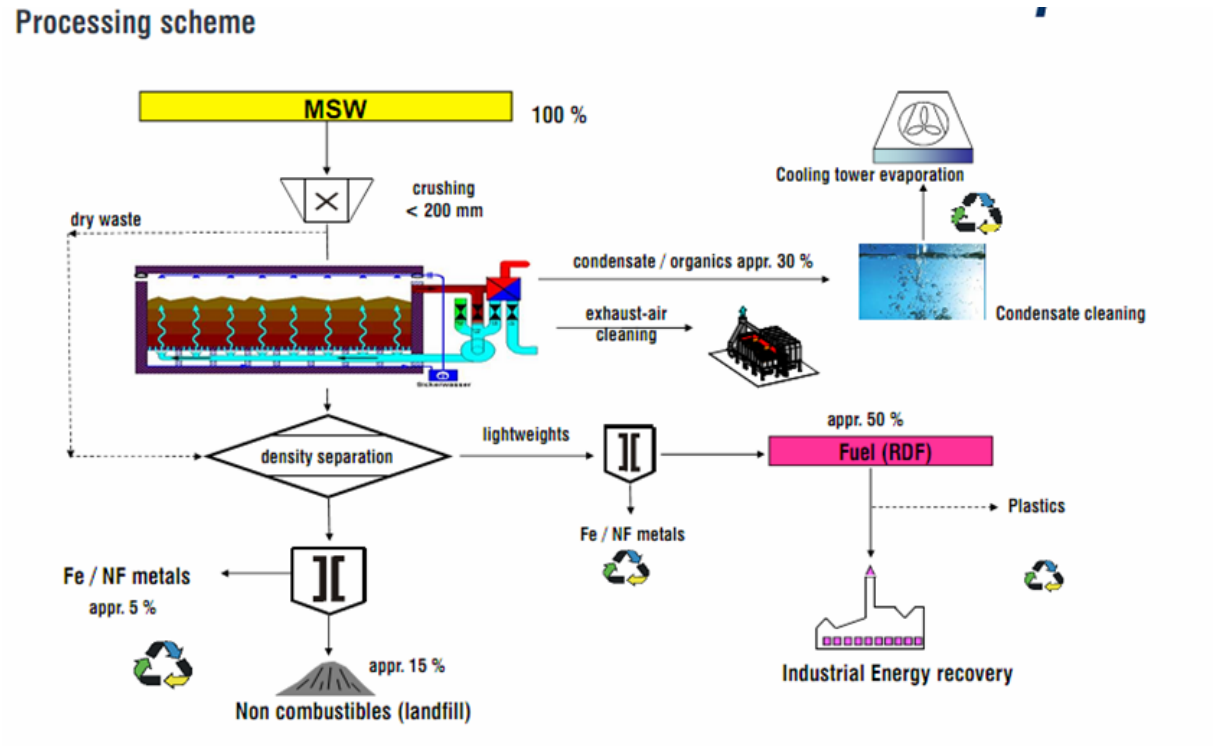

figure 18: Processing scheme of MBT-plant

2.2.3 Recycling, energy recovery and disposal

At the third stage the waste will be recovered (recycled or converted into energy) or disposed. The recycling concept flanked by MBT technology focuses on the production of secondary raw materials (paper, glass, metals and plastics), on the production of refuse derived fuel (RDF) and on the production of a stabilised residue which can be landfilled with less harm on the environment. This concept is highly flexible according to the output. In case of an emergency, when the MBT fails, the waste can be brought temporarily to the landfill. In times of low prices for paper or plastics, the production of RDF can be increased. If high profits from recycling of paper and plastics can be expected, the separate collection and sorting can be increased. This enables the municipality of KM municipality to keep the costs low and to safeguard deposition security.

It is obvious, that separate collection and sorting of recyclables and production of RDF depend on a market for this products and a functioning recycling industry. There are approaches by private entrepreneurs for the recycling of metals and paper. These activities should be supported by the municipality. For the recycling of glass, a glass factory in Surgut was identified. The eligibility of this plant for recycling activities should be verified. There are no activities in the recycling of plastics so far. A feasibility study to explore the possibilities should be initiated by the municipality. The municipality supported by the High Technology Park and other private investors should take the initiative to establish a recycling centre. In the framework of a competition private enterprises can be selected for different recycling activities.

The bigger challenge can be expected in the marketing of RDF. Solutions with co-incineration in cement plants or coal fired power plants are not eligible because of the huge distances and of quality constrains. A feasibility study should be initiated by the municipality in order to explore the efficiency and economy of a RDF plant for the production of steam to provide an industrial area or residential buildings.

2.3 Environmental impact

In Khanty-Mansiysk MSW is collected together with industrial and hazardous waste and disposed untreated on the local landfill site. Up to 30% of the MSW is disposed on uncontrolled dumpsites at the outskirts of KM municipality and have to be cleaned in regular intervals by municipal employees. Only medical waste is separately collected and treated in a sterilisation plant. Several risks and impacts on the environment are caused by the current waste management.

- Pollution of soil and groundwater from hazardous substances (persistent organic compounds and heavy metals) dissolved in leachate
- Production of climate-relevant greenhouse gas emissions (Methane, carbon dioxide etc)
- Air emission from uncontrolled fires on the landfill
- Risk of fire and explosion from methane gas emissions
- Land consumption by disposing increasing waste amounts

The proposed waste management concept will reduce the environmental impact significantly by implementing following management and technical measures.

- Strict separation of hazardous and non-hazardous waste from collection to disposal (implementation of collection systems or return opportunities for hazardous waste and safe opportunities for recovery & disposal)
- Implementation of maintaining systems to detect hazardous waste at the entrance of the landfill site
- Closure of illegal dumpsites for MSW and prohibition of any further uncontrolled disposal
- Separate collection of recyclables and sorting & processing of these materials to reduce the waste amount on the landfill site
- Mechanical-biological treatment of MSW by MBT plant to reduce the biological activity (methane production) and to reduce the waste amount to be disposed by separating recyclables and materials for the production of RDF

- Improvement of the existing landfill site and development to a sanitary landfill site which will meet European standards (according to EU landfill directive[44]).

The implementation of the proposed WMC will reduce the waste amount to be disposed in 2024 to 26.4% of the annual waste amount in 2012 and the greenhouse gas emission to 11% (related to the reference year 2012). The measures of strict separation of hazardous substances from MSW and the closure of uncontrolled dumpsites will reduce the impact of persistent organic compounds and heavy metals into the soil and groundwater of KM municipality. Additional environmental impacts from the operation of the MBT and the SPP are not expected. Both plants will be encased completely. The waste water from operating the rotting process will be re-circulated and the wastewater overflow will be treated. The waste air from the plant will be cleaned by respective exhaust air purification equipment (most probably bio filter). For more details on the environmental impacts from waste treatment plants see ***Annex II*** to this report.

2.4 Estimated costs

The implementation of the proposed WMC can only be successful and sustainable, if the municipality and the inhabitants of KM can bear the costs of the improved waste management system. In consideration of limited financial resources of the municipality and its inhabitants the concept recommended mainly easy and cost effective technologies. Furthermore the concept focuses on recycling to gain most benefit from waste management measures.

The calculation of the overall costs considers the implementation and operation of the following waste management components:

- Pick-up system for the collection of residual waste from households and commerce (mainly improvement of the existing system)
- Drop-off system for the collection of recyclables (paper, glass, metals, plastics)
- Sorting and processing plant for the treatment, manufacturing and selling of separate collected recyclables
- MBT plant for processing of residual MSW and production of recyclables, RDF and stabilized waste
- Construction of a new sanitary landfill or development of the existing landfill to a sanitary landfill site according to EU standards (according to EU landfill directive[45]).

The calculation does not include the proposed organisational and technical measures which are indispensable from the view of the protection of human health and the environment. Those measures include:

[44] Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, Official Journal of the European Communities, L 182/1, 16.07.1999, p. 0001-0019

[45] Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, Official Journal of the European Communities, L 182/1, 16.07.1999, p. 0001-0019

- The administrative costs for waste management
- Implementation of a public relation office for awareness raising (prevention, separate collection, environmentally friendly waste management)
- Import duties for technology of EU-countries
- Ban on mixing hazardous and non-hazardous waste
- Implementation of a location for hazardous waste on the landfill site
- Prohibition of dumping hazardous waste into the MSW containers
- Prohibition of disposing any waste on uncontrolled landfill sites and the respective control
- Implementation of a collection system for hazardous substances from private households and small business (e.g. < 500 kg per capita and year)

The estimated total costs subdivided into waste management processes for implementing the WMC are given in table 7. The investment and operation costs were obtained by requests from waste treatment plant manufacturers and from literature research. The cost ranges are due to the information of different producer, different plant designs and designs of collection systems, different environmental standards etc. The revenues are subject to strong fluctuations because of varying world market prices of raw materials.

The purchase price (excluding incidental expenses) for a simple and easy-to-manage technical design of a MBT plant (capacity of 30,000 to 40,000 tons per year), ranges between 6 and 10 million Euro. At an expected interest rate of 3.8% and an expected operating period of 15 years the annual investment costs are varying between 744 and 1,241 thousand Euros. The investment costs for a mechanical sorting plant largely depends on the plant design (basic, medium scale, sophistic scale). Therefore it is hardly possible to quote prices, for the achievable quality of the recyclables and the respective technology has to be defined previously. For the estimation of investment cost for sorting and processing we calculated with a cost range of 1.5 to 2.5 million Euro. The purchase price (excluding incidental expenses) for a sanitary landfill site (EU-standard) with an annual capacity of 50,000 tons, ranges between 8 and 12 million Euros. At an expected interest rate of 1% and an expected operational period of 25 years the annual investment costs are varying between 410 and 616 thousand Euros.

The total specific costs for the treatment of each ton of waste can be calculated from the investment and operation costs for each waste management process. The total specific costs per ton range between 77 and 103 Euro. Based on the results of the waste analysis, we can assume that one person generates 350 kg of MSW. The total costs for waste management per person can be calculated to 28 to 38 Euro per capita and year.

In table 7 the estimated costs for the status-quo is shown as well. For the status-quo it is assumed, that the pick-up system to collect MSW remains unchanged and the landfill site is improved according to EU standards (sanitary landfill site). The specific costs per person considering the status-quo for the waste management situation will range between 18 and 28 Euro in 2016. These costs correspond with the present data on costs for waste management

in KM, which are 23 Euro per capita[46]. The increase of waste management costs in 2024 is caused by the amount of MSW, which will exceed 50,000 tons in 2024. This amount of MSW will require further extension of the landfill site.

table 7: Estimated cost for the implementation of the WMC

Waste management process		Cost types	Specific costs		Recycling MBT				Status-Quo			
					2016 [1.000 €/a]		2024 [1.000 €/a]		2016 [1.000 €/a]		2024 [1.000 €/a]	
Waste Collection	Pick-up System	Invest	6 €/Mg	to 10 €/Mg	177	to 295	226	to 376	212	to 354	303	to 505
		Operation	20 €/Mg	28 €/Mg	590	826	753	1.054	707	990	1.009	1.413
	Drop-off System	Invest	10 €/Mg	14 €/Mg	48	67	103	144				
		Operation	12 €/Mg	20 €/Mg	57	96	124	206				
Sorting & pre-treatment	Metal	Invest&Op.	100 €/Mg	135 €/Mg	138	187	200	270				
	Paper	Invest&Op.	25 €/Mg	60 €/Mg	37	88	77	185				
	Glass	Invest&Op.	25 €/Mg	60 €/Mg	55	132	113	271				
	Plastics	Invest&Op.	130 €/Mg	210 €/Mg	201	324	402	650				
Waste Treatment	MBT	Invest	25 €/Mg	41 €/Mg	744	1.241	993	1.654				
		Operation	15 €/Mg	25 €/Mg	450	750	600	1.000				
Waste recycling & Eny. recovery	Metal	Revenue	170 €/Mg	220 €/Mg	-235	-304	-340	-440				
	Paper	Revenue	70 €/Mg	140 €/Mg	-103	-205	-215	-431				
	Glass	Revenue	32 €/Mg	70 €/Mg	-70	-154	-145	-316				
	Plastics	Revenue	150 €/Mg	250 €/Mg	-232	-386	-464	-774				
	RDF	Revenue	-25 €/Mg	25 €/Mg	250	-250	317	-317				
Disposal	Landfill	Invest	10 €/Mg	15 €/Mg	410	616	410	616	410	616	518	777
		Operation	10 €/Mg	to 18 €/Mg	109	197	133	240	354	636	505	908
Total			**77 €/Mg**	**103 €/Mg**	**2.627**	to **3.518**	**3.286**	to **4.389**	**1.683**	to **2.595**	**2.334**	to **3.602**
Total per person					**28 €/p**	**37 €/p**	**28 €/p**	**38 €/p**	**18 €/p**	**27 €/p**	**20 €/p**	**31 €/p**

Parameter:		2012	2016	2024	
	Inhabitants KM	80.000	95.500	115.700	
	Quantity of MSW	28.000 Mg/a	35.000 Mg/a	50.000 Mg/a	1.000.000 Mg for landfill
	MSW per person	350 kg/p*a	366 kg/p*a	432 kg/p*a	
	repayment period	15a			25a for landfill
	Interest rate	3,8%			1,0% for landfill

Furthermore the applicability of the **C**lean **D**evelopment **M**echanism (CDM) to reduce waste management costs should be examined. The CDM, defined in Article 12 of the Kyoto Protocol, allows a country with an emission-reduction or emission-limitation commitment to implement an emission-reduction project in developing countries. The implementation of recycling activities and the mechanical-biological treatment of residual waste will contribute to the reduction of CO2. Therefore the waste management project in KM municipality can earn saleable certified emission reduction (CER) credits. The benefit of CDM projects in the waste management sector can range between 8 to 10 Euro per Mg.

Moreover, the improved waste management system in KM municipality will reduce the waste being disposed on the landfill site to 26% of the waste amount generated. This means, that the regional government, which is responsible for landfill sites in the KMAO-Ugra, has to spend less money in the construction of new landfill sites or in the improvement of existing sites. For this reason, the department of city household should apply for a grant for the investment of the SPP and/ or MBT plant. Assuming the town of KM municipality will receive

[46] Department for City Household: According to the charge for disposal (regulation No 85; 16.11.2010) and the charge for collection and transport (protocol from 29.12.2010), $1m^3$ of municipal solid waste (including collection, transport and disposal) costs 486.67 Roubles (12.81 Euros; 1 Euros = 38 Roubles). Relating the norm of production of waste in KM (from 29.12.2006), $1.754m^3$ of municipal solid waste per year were produced of each inhabitant. In total, 858.49 Roubles (23 Euros) per year has to be paid by each inhabitant of KM for collection, transport and disposal municipal solid waste.

a grant of 2 to 3 million Euro for the MBT plant, the total quantity-specific costs for waste management will be reduced by approximately 8 to 10 Euro per Mg.

3 FEASIBILITY ASPECTS OF THE WASTE MANAGEMENT CONCEPT

The proposed waste management concept is based on the information about waste quantities and qualities, available and approved technologies, legal requirements, the current waste management infrastructure and other economic and geographical conditions. Furthermore ecological and social aspects have been considered. Despite all of this there are specific issues, which have to be clarified by additional feasibility studies before the concept can be implemented. Following aspects should be subjected to a more detailed examination.

- Approved technology under severe climate conditions
- Financing of the waste management measures (socio-economic aspects)
- Compatibility with the regional concept
- Establishment of a recycling industry and a sales market for recycling products and RDF

3.1 Approved technology under severe climate conditions

The representatives of KM municipality administration expressed serious concerns about the biological treatment under the severe climate conditions in Siberia. For that reason a survey has been conducted to ask experts in countries with similar climate conditions. Alaska, Canada, Norway, Sweden and Finland have been selected. MBT technologies are being used successfully in Canada and Finland. The experts confirmed, that by considering aspects of technical design and particularly good operational management composting or digestion of MSW is possible. Furthermore providers of MBT technology in Germany have been asked for their experience with these technology under severe climate conditions. Even in this case, it was confirmed, that there are no concerns using this technology in Siberia. For more details see ***Annex IV*** to this report.

3.2 Financing of the waste management measures

After the determination of the final concept and the calculation of the expected costs the financial burden for the municipality and its inhabitants has become clear. According to the calculation in chapter 2.4 (table 7), the total quantity-specific costs for WM range between 77 and 103 Euro per Mg and annum. Assuming, that on the one hand, 15 to 20% of the costs has to be covered by commerce and industry and on the other hand administration costs will increase the expenses by approximately 25% and import duties on technical equipment will also increase the estimated WM costs, the average costs per ton covered by private households will range between 89 and 121 Euro per annum. Currently the inhabitants of KM municipality have to pay 67.2 EUR per annum for the waste management. According to the estimation given in table 7, the range of total costs for each person varies between 53 and 82 Euro per capita and annum for the status-quo.

Keeping in mind, that the increase of the fee for waste management in Russia is limited to 18% per year, it seems feasible to increase the fees to the level needed for the WM system the financing of the waste management measures proposed by the WMC.

As mentioned in chapter 2.4 grants can be applied for CDM and reduced landfill site volume. Revenues in a range of 8 to 10 Euros can be gained from the climate development mechanism (CDM-projects). Considering, that the improved waste management system will generate just a third of the MSW of the current system, it could be expected, that the regional administration supports the investment of the recycling and MBT activities. Costs saved for the landfill site could be rededicated to implement the MBT plant. Assuming KM municipality will receive grants for CDM and reduced landfill costs, the households of KM municipality (3 persons in average) has to spend between 73 and 98 Euros for the improved waste management system. That would amount to, that the costs for advanced waste management will increase by approx. 25% compared with the current costs. These considerations should be evaluated in a further feasibility study.

3.3 Compatibility with the regional concept

As the regional waste concepts principally describes the main idea of dealing with waste in the entire region KMAO-Ugra, it does not clarify a detailed urban waste management concept (compare also chapter 2.1.7; Regional concept). However, the regional concept also formulates essential waste treatment strategies for KM municipality.

On the one hand, the regional and the urban waste management concept demonstrate very similar purposes: the reduction of environmental pollution through the reduction of waste amount disposed on the landfill as well as the implementation of recycling respectively.

Regarding implementing on the other, both concepts also show compatibility within:

- Implementation of separate collection of municipal waste: Containers for residual and for recyclable waste will be put up as well as a centrally located recycling centre will be constructed.
- Separate collection of similar secondary raw materials: The main emphasis of a separate collection and treatment is put on the waste fractions paper, plastic, glass and metals.
- Extension of current landfill site and implementation of engineering standards on the landfill: Expanding the landfill is essential in order to extend the operational time of the landfill. Furthermore, necessary engineering standards such as landfill base sealing system will be implemented.
- Implementation of collecting points for hazardous waste: Within both concepts the implementation of a hazardous collecting point is described.
- Implementation of a shredding treatment machine: The regional concept as well as within the description of the improvement of the landfill plant (compare 4.2.5; Improvement of landfill site) describe to implement a shredder to treat the bulky waste in order to heighten up the capacity of the landfill.

Nonetheless, the regional waste management concept and the WMC for KM municipality demonstrate different overlapping, especially in the objectives and in various implementation strategies.

3.4 Establishment of a recycling industry and a sales market for recycling products and RDF

There are small recycling-activities in Khanty-Mansiysk on collecting and dealing with scrap metal and waste paper. Recycling of plastics and glass is not implemented yet. The information obtained in the framework of the market analysis (refer to ***Annex I***) showed, that the small amounts of recyclables and the huge distances to the end user (steel mill, paper mill, glass factory, cement factory etc.) are the main obstacles. Apart from these more logistical problems, the market analysis shows that secondary raw materials are demanded and that the prices will raise in future.

In order to allocate economically viable amounts of recyclables and to reduce the shipment cost to the end user the local player in the recycling business should co-ordinate and concentrate their activities. The regional waste management concept and the WMC of KM municipality promotes separate collection and recycling. Therefore it could be expected, that a well-developed logistical concept, supported by the regional administration could overcome those difficulties.

Key points of a regional logistical recycling concept could be source separation and civic amenity sites in the bigger towns of the region, civic amenity sites in the villages, recycling centres in central located towns and a central transhipment point. Development and implementation of recycling activities in the region should be supported by the regional administration thru a feasibility study. Moreover incentives for enterprises are conceivable to initiate recycling activities. Incentives could be subsidised loans, building plots or support by the development of a business plan by the high technology park.

4 RECOMMENDATIONS FOR THE IMPLEMENTATION OF THE WASTE MANAGEMENT CONCEPT

The implementation of the proposed WMC requires a number of measures to be initiated by the administration of KM municipality. These include administrative and organisational measures such as prohibitions, incentives, guidelines, monitoring of measures etc. and technical measures such as the implementation of a new collection system, the construction of waste treatment and recycling plants and/ or the improvement of the landfill site. All these measures have to be adjusted and realised in a binding step-by-step plan.

Some of the waste management activities from collection to final disposal can be transferred to private companies or can be carried out in private-public partnership (PPP-models). The collection of recyclables, the operation of sorting and processing plants for recycling materials and the marketing of these materials could be fields of activity for private enterprises. To avoid risks to health and the environment private companies working in the waste management sector should be licenced and their activities should be monitored by the responsible supervisory authority.

4.1 Administrative and organisational measures

The administrative and organisational measures include provisions to the separation of hazardous waste, provisions to keep recyclables separate and to put them into the provided receptacles, measures for waste prevention, preventions to keep hazardous and non-hazardous waste separate on the landfill site etc.

4.1.1 Awareness raising and public relation

In discussions with representatives from the local administration and the Ugra state university it became clear, that the awareness level of the population regarding municipal waste management and their own responsibility for a clean environment and waste reduction is presently very low. The willingness to participate in waste minimisation and waste separation is low as well. As long as there is no possibility to introduce waste related fees, there is no instrument to offer incentives for those who comply with the system.

We propose to carry out awareness raising campaigns to educate the public about the requirements of MSW management, thus increasing the acceptance and cooperation of the population for the required MSW management measures and their willingness-to-pay cost covering fees/taxes for MSW management.

Furthermore a Public Relation centre should be established at the department of city household for continuous information of the population of KM municipality on specific waste prevention measures, separate collection of recyclables, safe and environmentally friendly disposal possibilities for hazardous waste etc.

4.1.2 Strict separation of hazardous and non-hazardous waste

Waste of modern industrialised societies includes remarkable amounts of hazardous substances. Hazardous waste is generated by industrial processes and by the use of specific products such as colours, batteries & accumulators, motor oils, solvents etc. To avoid risks for human health and to protect the environment hazardous waste should be kept separately by the generator and shouldn’t be mixed up with MSW.

Consequently collection and transport systems have to be provided by the municipality. Hazardous waste from private households can be collected by specific vehicles in regular intervals or can be brought to civic amenity sites as described in section 2.2.1. Commercial and industrial enterprises have to be obliged to put their hazardous waste into a save interim storage or to bring their hazardous waste to a save disposal area on the landfill site. The responsible authority has to monitor the hazardous waste management and to safeguard that no environmental harm is caused by the activities with hazardous waste.

4.1.3 Measures for waste prevention

Waste prevention is supposed to have the highest priority in waste issues and strategies. However, in an industrial society, the emergence of waste can not be fully prevented. But there are numerous technical and organisational arrangements to avoid at least a part of the remains from industries and the hazardous substances they may contain. Waste prevention measures can be generally classified into three sections:

(1) Re-use of products or extension of the lifetime of products

(2) Reducing the hazardous effects of the generated waste on the environment and human health

(3) Reducing the concentration of hazardous substances of product content

The public authorities can undertake certain measures in order to reduce the waste amount generated by private households, businesses and industries. For example:

- Encouraging and supporting the formation of a re-use and repair networking (including e.g. returnable packaging/bottles, second hand markets, etc.),
- appliance of
  - economic instruments (e.g. taxes, disposal fees),
  - procurement criteria (e.g. resource-saving-, low emission-products; introduction of eco-labels) and
  - quantitative aims (e.g. political targets in waste reduction or limiting values).

The prospects to prevent waste at the household level and in the industries lie mainly in prevention by quality and quantity of consumption. Authorities are supposed to inform the citizens about environmental consequences of their consumption behavior. With an awareness of sustainability, consumers can pay attention to buy products with less packaging, beverage in returnable packaging and to prefer sustainable products. Also the establishment of second hand markets for clothes, furniture etc. are a good tool to enlarge the lifetime of products and reduces waste significantly. But longer use of items implies that ecological quality products are achievable on the market. In order to achieve this, waste consultations and incentives for technical innovation (new technologies with less waste generation) should be offered to producers and industries. Additional to longer use of products, ecological production patterns and product design has to be applied.

Also the public sector has a great potential in reducing waste amounts. Especially “green procurement” is important, because of the high demand of different products in the public sector (from pencils and paper to trains and busses).

Initiatives for Waste prevention should be always structured, coordinated and if possible a cooperation of different projects, otherwise the undertaking could be not efficient.

4.2 Technical measures

4.2.1 Improvement of pick-up system/ arrangement

A pick-up system/ arrangement for the collection of MSW is already implemented and can be used for the WMC envisaged. The adaptation/ improvement of the pick-up system is recommended due to changing waste flow caused by separate collection. It is also recommended to renew the receptacles for MSW and to replace the waste collection vehicles step-by-step. A selection of appropriate waste containers and vehicles is listed and described in ***Annex II*** to this report.

4.2.2 Implementation of drop-off system/ arrangement

A drop-off system/ arrangement to collect the recyclables paper, glass, metals and plastics has to be established (possibly by local waste collection company). It is not obligatory to collect these four fractions from the beginning. It is conceivable to start with paper and metals, because for these materials it is more likely to find a short-term solution for marketing. It is also not obligatory to collect the materials in separate containers. At the beginning the collection could start with one receptacle for all recyclables. But keep in mind, that the mixed collection will reduce the material quality and therefore the achievable revenues as well.

All these questions should be investigated in a pilot project. It is recommended to introduce a separate collection system for paper and metals or glass in a limited area of KM municipality. Therefore a common container in the drop-off system/ arrangement for all included recyclables should be introduced. The area should not have more than 3.000 inhabitants. Preferably it should be in an area with middle and high income, because for these regions a higher motivation to support the project could be expected. If required, the pilot project could be extended by a drop-off system/ arrangement for separate collection for each material flow.

After the successful completion of the pilot project applicable container and vehicles has to be selected and purchased to collect the recyclables all over KM municipality. A selection of appropriate waste containers and vehicles is listed and described in ***Annex II*** to this report. Considering the calculated waste amounts for metals, glass, paper and plastics, up to 100 container locations has to be determined and equipped with container. The calculation of the number of container needed for the separate collection can be taken from table 8. In case, that all recyclables should be collected in one receptacle, the volume or collection frequency of these containers has to be adapted.

The bring banks should be easily accessible for the inhabitants in KM municipality. On the other hand, the costs for the collection of recyclables should be kept as low as possible. Successful locations are sites with a high visibility and a high frequency of customer traffic such as near shopping centres or parking areas. Special care must be given to the regular cleansing of these sites.

From practical experience it can be claimed, that the quality of separate collected materials is correlated to income and level of education and residential areas, to the type of the collection system and to the recycling rate. The quality is decreasing in areas with low income and level of education. Pick-up systems will rise the amount of recycling material but often decrease the quality (frequently MSW is disposed in the recycling bins). And it is of great importance to keep the bring banks clean, because otherwise people are not willing to use these places for the disposal of their recyclables. The figure 19 illustrates the distribution of bring bank stations in KM municipality (section).

table 8: Example for calculation of needed number of containers, volume and collection frequency

Material flow type		2012	2016	2024
Mass	metal	129 Mg/a	462 Mg/a	1.052 Mg/a
	paper	307 Mg/a	1.462 Mg/a	2.996 Mg/a
	glass		1.788 Mg/a	3.665 Mg/a
	plastics		1.060 Mg/a	2.318 Mg/a
Volume	metal	12 m3/w	44 m3/w	101 m3/w
	paper	30 m3/w	141 m3/w	288 m3/w
	glass		138 m3/w	282 m3/w
	plastics		340 m3/w	743 m3/w
Number of Container	metal	12	44	101
	paper	10	47	96
	glass		46	94
	plastics		68	149

Density:

metal	0,20 Mg/m3
paper	0,20 Mg/m3
glass	0,25 Mg/m3
plastics	0,06 Mg/m3

Container volume:

metal	1 m3
paper	3 m3
glass	3 m3
plastics	5 m3

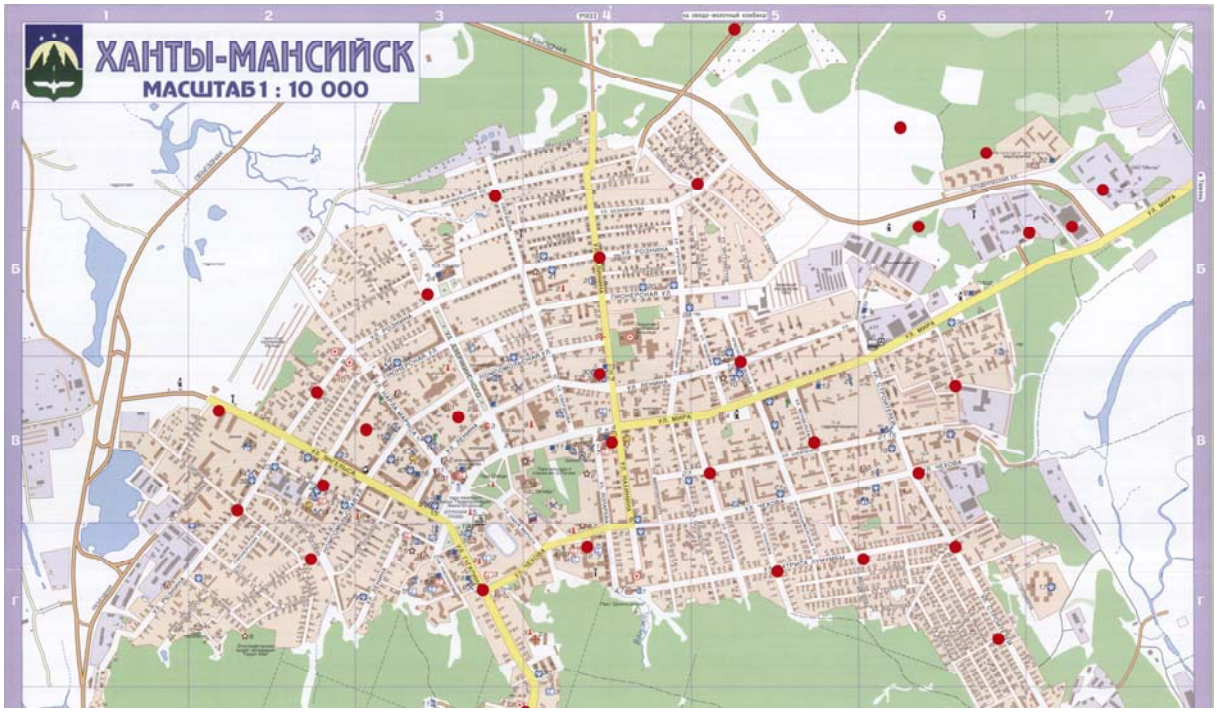

figure 19: Proposal for the distribution of container in Khanty-Mansiysk – drop-off system for the collection of recyclables (section)

Various options to implement waste collection systems are described in ***Annex II*** to this report.

4.2.3 Implementation of MBT plant

The core element of the WMC for Khanty-Mansiysk is the Mechanical-Biological Treatment plant (MBT). The framework conditions for the capacity and the technical design were worked out in the status-quo report (***Annex I*** to this report). The planning, design and construction of the MBT plant has to be commissioned to an experienced company. For preparation of the tendering process a selected number of companies can be invited to introduce their technological concepts of mechanical-biological waste treatment. Additionally responsible stuff of the KM municipality administration can visit running MBT plants to get an impression and to inform themselves about the most recent technological developments.

The next step is the preparation of the tendering procedure. The information worked out in the framework of the Russian-German WMC-project, such as the status-quo report, description of the WMC, additional information on waste properties, market conditions for recyclables and RDF, project budget etc. is available and can be used for the technical specification of the tender documents.

Another important step in the implementation process of the MBT plant is the search for a suitable location. A common procedure for the identification of suitable sites for waste treatment plants is the negative selection method. During this procedure at first all locations which are not eligible will be excluded. In the next step the remaining locations will be assessed by determined criteria, fixed before starting the selection process. Among these criteria are costs, transport connections, distances of transportation routes, impact on residential areas (noise, smell etc.) and other available infrastructure (electrical power, water and waste water, etc.). The respective information can be taken from the detailed status-quo report (***Annex I***).

During the planning phase of the MBT plant the adjustment with other affected resorts (environmental impact assessment, construction permits etc.) has to be considered. Another critical point is the public acceptance of waste treatment plants. Therefore the implementation process has to be carried out with participation of the inhabitants of KM municipality and needs to be well communicated.

4.2.4 Implementation of sorting & processing plant

Implementing the sorting & processing plant the same procedure can be used as for the MBT plant. It is recommended to find private investors and operators for the recycling facilities. Theses services should be tendered by the municipality. For the municipality will remain responsible for the waste disposal, the tasks and services to be fulfilled by prospective contractors should be well prepared and formulated. It should include guaranties for the processing of minimum quantities and the compliance with environmental standards. The failure of the recycling activities will mean, that the separate collected recyclables has to be processes in the MBT plant or disposed on the landfill site. This will cause additional costs, which has to be paid by the citizens of KM municipality.

4.2.5 Improvement of landfill site

In Khanty-Mansiysk, there is only one governmental landfill (TBO landfill) for the disposal of MSW for the town and surrounding villages. The current technical standards are described in the status-quo report (***Annex I*** to this report).

The prepared places for disposal of municipal solid waste on the landfill site are already filled above capacity. New waste disposal areas are being prepared at the moment. However, the geological conditions of the area around Khanty-Mansiysk limit the area for waste disposal sites.

The existing landfill can be used as a part of the waste management concept. Since the places prepared for waste disposal are filled and the regional concept also includes extending the landfill to an inter-communal landfill, it is recommended that the landfill should be further developed into a sanitary landfill site. A sanitary landfill is an isolated site where waste is disposed of away from the environment. The aim is to reduce the negative impact of the landfill site such as the pollution of ground- and surface water, soil, and air, caused by incorrect waste disposal. Therefore, improvements for operational and technical requirements are described.

The following characteristics already exist and in some cases, an improvement is necessary:

- ***Office:*** An office is recommended where the documents of waste can be checked as well as the register of waste can be recorded; i.e. the recent office has to be enhanced.
- ***Access and temporary roads:*** The existing access road as the surrounding area of the landfill site should not be polluted through the waste disposal of the landfill. The current temporary road should be built in a way that its surface can be ensured access to the waste mound in all weather conditions and provide adequate surface water drainage.
- ***Weighbridge:*** The existing weighbridge at the entrance of the landfill site for measuring the waste amount in Mg should be kept on.
- ***Steel-wheeled waste compactor machine/ landfill compactor:*** The waste deposited on the prepared places is already compacted. Nevertheless, waste should be disposed of in layers and compacted in order to heighten up the capacity of the waste disposal site.
- ***Tyres sanitary wash:*** A tyres sanitary wash already exists at the exit of the landfill site; it should be maintained.
- ***Fences:*** The existing fencing around the landfill site should be kept on and reinforced to avoid the appearance of animals (and illegal waste disposal). Furthermore, the existing moveable fences should be used to catch the litter, followed by manual cleaning of the litter.
- ***Trained staff:*** The staff should be trained to supervise the preparation and construction of the waste disposal site, the depositing of waste and the regular operation and safeguarding of the entire landfill site.

In addition to the above existing features of the current landfill site, it is recommend to carry out the following features:

- ***Inspection of waste at delivery including its identification and immediate screening:*** In contrast to the waste amount, the waste composition (of the waste transported to the landfill) is not recorded yet at the entrance of the TBO landfill in Khanty-Mansiysk. Therefore, waste screening at the landfill site should be implemented. If the waste transported to the landfill is not municipal solid household waste as per definition, a sampling and quick analysis of pollutants should be carried out in order to avoid ecological problems and to identify on which place the waste should be disposed. Furthermore, a laboratory (see also below) should be implemented for quick waste analyses.
- ***Collection of leachate and gas:*** For a landfill site extension, formal engineering preparations (provision of leachate and landfill gas management systems) on the basis of geological and hydro-geological investigations should be realised. Surface and groundwater have to be protected through geological bunds and base sealing system during the operational time. Engineering measures such as landfill gas vents, drainage and bunds to minimise the lateral movement of pollutants should be constructed to control emissions of leachate and landfill gas from the site.
- ***Laboratory:*** In the laboratory, the meteorological information and the data of emission from the monitoring equipment of leachte and landfill gases can be recorded.
- ***Top cover remediation:*** The waste disposal site should be covered daily with either inert material or fully decomposed waste to minimise odours, flies and vermin and to keep birds and animals away from the landfill site.
- ***Landfill plan for waste disposal and a register:*** A plan for the current and further location of waste disposal should be prepared. Furthermore, a landfill plan including operation, cellular filling and temporary roads should be developed. In addition, a register/ index of waste delivered need to be implemented. It includes:
  - Amount and composition of waste
  - Origin and date of delivery
  - Name of the producer or name of waste disposal company by delivery of MSW
  - For the case of hazardous waste: the exact place of disposal on the landfill.
- ***Systematic division of waste disposal:*** The landfill site should contain places for three different types of waste including their special prepared base sealing system, for hazardous waste in particular. The risk of an environmental contamination caused by hazardous waste is higher than from MSW or inert waste. Therefore, the demands of these prepared places regarding features (such as the system of collection of leachate and monitoring system) and operation are higher. Such a systematic division reduces significantly the environmental, health and safety risks at a landfill and can increase the landfill capacity. The division should include:
  - Places for non-hazardous waste; including municipal waste
  - Places for inert waste; and
  - Places for hazardous waste, including treated medical waste.

As described above, a sanitary landfill requires different features. Furthermore, the waste which should be disposed of on the landfill should also be checked in order to avoid environmental pollution and risks to human health. That include for disposal of:

- ***Residual waste from households and commerce:*** These types of waste could be disposed of in the landfill without being treated. However, for reducing the volume and risks to environment and human health, the waste types should be treated (i.e. in a MBT) before disposal.
- ***Residual waste from recyclables paper, glass, metals and plastics:*** compare "Residual waste from households and commerce"
- ***Hazardous waste from private households:*** As the existing hydrology plus the vast area of wetlands in the area around Khanty-Mansiysk extremely increase the risks of polluting the surface and ground water, it is recommended to only implement a temporary disposal of hazardous waste. The hazardous waste should be treated before disposal. It should be collected separately and treated in a thermal, physical-chemical or biological method in order to destroy, concentrate or immobilise the hazardous waste. An example is that this type of waste could be burned in incineration plants of oil companies which are located close to Khanty-Mansiysk (hazardous waste such as oil, paints etc.).
- ***Bulky waste:*** Bulky waste is often very suitable for recycling and very often consists mainly of wood that can be used for energy recovery. Shredded bulky waste requires more handling and consumes less volume than unprocessed bulky waste. Therefore, the capacity of the landfill can be maintained with using a shredding treatment machine for bulky waste.
- ***Construction & demolition waste/ inert waste:*** Inert waste is also very suitable for recycling. Inert waste, such as demolition waste, can be crushed and used for aggregates or engineering fillings; residues can be disposed of on the landfill site.
- ***Industrial waste:*** for non-hazardous industrial waste - compare "Residual waste from households and commerce"/ for hazardous industrial waste – compare disposal of "Hazardous waste from private households"
- ***Street cleaning residues:*** compare "Residual waste from households and commerce"
- ***Medical waste:*** Medical waste should be treated before disposing at places prepared for hazardous waste via the medical waste treatment plant "Newster" of the hospital in Khanty-Mansiysk.
- ***Other special waste types:*** compare "Hazardous waste from private households"

Regarding the ***current places which are full of waste***, it is recommended to cover the entire place with a top sealing system and to implement bunds to prevent ingress of surface water inflow and outflow of contaminated surface water from the site. This would minimise the risk to human health and the environment.

In conclusion, careful planning and professional standards of design, construction and an efficient operation carried out by trained staff lead to a safe, cost-effective and environmentally acceptable landfill site.

4.3 Time schedule for implementation of the project

The waste management concept has to be developed by a step-by-step implementation plan. It is proposed to start with the necessary organizational and administrative tasks. Among them the introduction of separate collection for hazardous waste from private households, the prohibition of mixing hazardous and non-hazardous waste, the implementation of a monitoring system for hazardous waste, the implementation of a deposition possibility (at least intermediate) for hazardous waste, consultation of commercial and industrial companies how to avoid and manage hazardous waste etc. Furthermore it is proposed to separate waste important in volume from MSW. Waste important in volume, such as construction & demolition waste or other mass relevant mineral waste types from industrial production should be collected and disposed separate from MSW to save valuable volume on the sanitary landfill site.

The implementation of the separate collection system for recyclables can be started as soon as a solution for the further sorting, processing and marketing is established. It is recommended to hold discussions with interested parties from the private sector, with the High Technology Park and with the respective industries for natural resources in order to make sure, that the separate collected materials are not disposed together with MSW. The motivation of the population of KM municipality can hardly be restored, if the separate recyclables are not used in a proper way.

The implementation of the sorting and processing facility should be started in parallel to the implementation of the separate collection of recyclables. It is recommended to start with small units which can be extended to the expected maximum material flow for these materials (see section 2.1.3, prognosis).

The implementation of the MBT plant has to be prepared carefully. For the construction of the MBT plant the same requirements applies as for the implementation of the separate collection. It should not be started with the production of RDF before a market for using these fuels is found. The detailed implementation plan for the waste management concept is shown in figure 20.

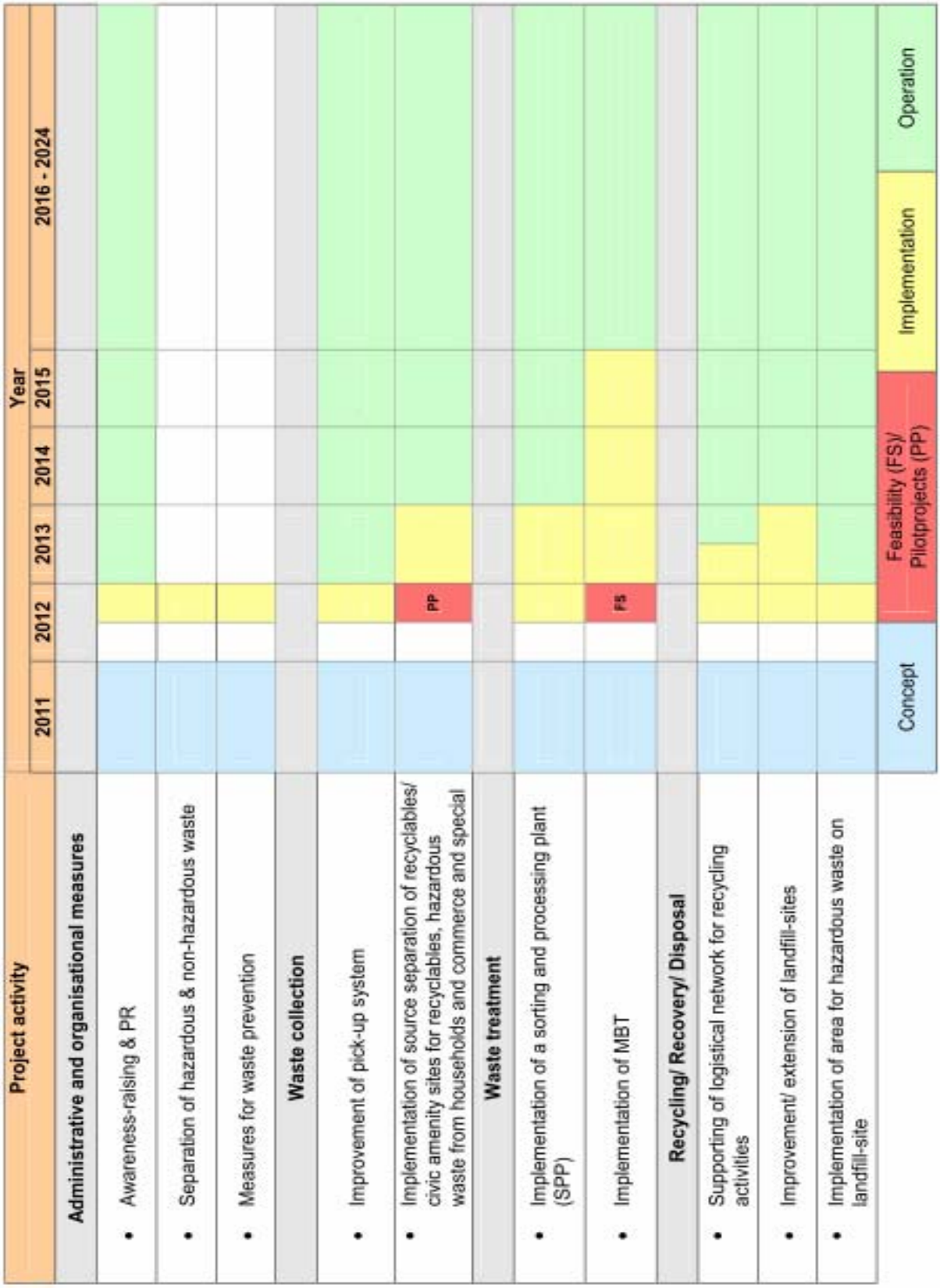

figure 20: Implementation plan for the waste management concept in Khanty-Mansiysk

5 SUMMARY

The management of municipal solid waste is one of the main problems for the public administration in Khanty-Mansiysk because the current methods of waste disposal have reached their limits. Therefore, a Russian-German project was initiated. The project has been supported and financed in the framework of the "Advisory Assistance Programme for Environmental Protection in the Countries of Central and Eastern Europe, the Caucasus and Central Asia" by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). It was agreed to develop a sustainable urban waste management concept in Khanty-Mansiysk that aims at protecting human health, reducing environmental pollution and achieving a minimised use of natural resources. Furthermore the concept safeguards disposal security and a significant reduction of waste to be landfilled.

For the development of a sustainable waste management concept, relevant data and information about main waste flows and their properties (quantity and quality of waste generated, recycled and disposed), infrastructure of Khanty-Mansiysk, geographical/ geological and topographical conditions, existing waste management structure (collection, transportation and treatment/ disposal), national/ regional waste legislation and opportunities for recycling products were collected or analysed respectively.

Based on data of the current waste management situation a baseline scenario and three waste treatment options (recycling scenario, incineration scenario and biological-treatment scenario) were developed and proposed. Following the results of discussions with representatives of the Khanty-Mansiysk administration the recycling scenario was selected, has been carefully developed and was approved in December 2011 by the Department of town-planning, architecture and housing and communal services of KM municipality[47].

The Russian-German advisory project focuses on the development of a waste management concept for municipal solid waste from private households and commerce (Household waste and waste similar to household waste). Industrial waste, hazardous waste and waste relevant in volume (e. g. construction and demolition waste) could not be further investigated in the framework of the project.

The recycling scenario consists of an advanced collection system for recyclables at source, a sorting and processing plant for manufacturing recyclables, a MBT plant to stabilise the waste, to produce RDF and to reduce the volume and environmental risks of waste to be deposited and the improvement of the existing landfill site to a sanitary landfill site which meets the EU standards. The effects of the implementation of the proposed waste management concept are:

- Reduction of the amount of MSW from expected 50 thousand tons per year without improved waste management (baseline scenario) to estimated 13 thousand tons per year after establishment of proposed WMC (recycling scenario)
- Additionally recyclables (up to 12.7 thousand tons) and secondary fuels (up to 12,7 thousand tons) can be produced.

[47] Note: This department was re-named in January 2012. The current name is: Department of city household – Administration of KM municipality.

- Significant reduction of risks to human health and the environment. Among them are, waste prevention by awareness raising campaigns, separate collection and treatment of hazardous waste to minimise the risks for groundwater and soil pollution, climate protection by avoidance of methane gas production at landfill site and efficient management of natural resources and energy by recycling activities.
- The annual costs for an advanced collection system, the implementation of a sorting & processing plant for recyclables, a MBT plant and the strengthening of the landfill site are estimated in the range of 2.6 to 4.4 Million Euro.
- The specific costs per capita will range between 28 and 38 € per annum.

The implementation of the waste management concept includes organisational and technical measures. Before implementing the separate collection and the MBT plant further feasibility studies and pilot projects should be stipulated. Especially the marketing conditions for recyclables and RDF should be investigated more deeply. Before starting with the separate collection of metals, paper, glass and plastics, the motivation of the population, the achievable collection rates, the quality etc should be analysed by a pilot project in a defined area of Khanty-Mansiysk. Following key points for the project implementation were proposed:

- Administrational measures
  - Awareness raising campaign (2012)
  - Prevention (2012)
  - Mixing ban for hazardous waste (2012)
- Feasibility study
  - Establishment of recycling industry (2012 - 13)
  - MBT plant (2012 - 13)
- Pilot project
  - separate collection at source (2012)
- Improvement of existing pick-up system (2012)
- Implementation of separate collection at source (2013)
- Implementation of S&PP (2013)
- Implementation of MBT (2014 – 15)
- Improvement/ extension of landfill site (2012 – 14)

Main obstacles to implement the proposed waste management concept are the establishment of a functioning recycling industry (small and widely spread amounts of recyclables/ RDF and distances to the market, demand for RDF), the financing of the proposed measures (sustainable financing, adaptation of fees for waste management) and to motivate and convince the citizens of Khanty-Mansiysk to participate in the separate collection system. Therefore an awareness raising campaign and continuous public relation activities has to be initiated by the local administration of KM municipality.

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